Two New Physiological Methods to Assess the Specificity of Sexual Responses

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Author Declaration

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Megan Leona Sawatsky

Abstract

Psychophysiological methods to study sexual response patterns in laboratory settings have revealed an intriguing, and puzzling, gender/sex difference in the *cue-specificity* of genital responses. Men's penile responses differ across stimuli depending on the presence or absence of specific sexual cues (e.g., gender and age of individuals in a sexual stimulus), with substantial responses observed for cues that correspond with sexual preferences and much less response to nonpreferred cues. This is not the case for women. Women's genital responses (vaginal vasocongestion) are elicited by almost any sexual cue and the response magnitude is much less affected by sexual preferences, particularly for heterosexual women. Even sexual stimuli rated as sexually non-arousing and unappealing can elicit substantial vaginal responses. These findings have inspired several research questions. In particular, what is the function of relatively low cue-specificity in women? Are gender/sex differences in cue-specificity an artifact of the methods used to assess genital responses in women and men? The four studies in this dissertation address these questions by employing two novel devices to measure either genital lubrication or anal vasocongestion. Results from two studies suggest that the degree of cue-specificity in women depends on which aspect of the genital response is assessed: Genital lubrication was specific to preferred sexual stimuli, whereas vaginal vasocongestion demonstrated low cue-specificity across the entire stimulus duration. The other two studies focussed on developing and testing methodologies related to anal photoplethysmography. The results indicate that, in its current configuration, it would be premature to use anal photoplethysmography to study gender/sex differences in sexual response patterns. Taken together, the research program highlights the impact of measurement devices on sexual response patterns and underscores the importance of a multidisciplinary, multi-methodology approach to studying sexual response patterns in women and men.

Preface

In addition to the General Introduction and General Discussion chapters, this dissertation comprises four scientific reports in separate chapters. Versions of the reports are either published or under review for publication. The references below provide relevant publication information. Formatting, language, and referencing styles are consistent with the standards of the journal to which the reports were submitted. Tables, figures, and references are presented at the end of each report. All reports were written in full by the first author. Dr. Martin Lalumière was a co-author for all reports and served as the dissertation supervisor; he contributed to study planning, conceptualisation, and editing of drafts.

Chapter Two is published in *Biological Psychology* and was co-authored by Dr. Samantha Dawson. Dr. Dawson contributed to the conceptualisation and provided manuscript feedback and editing. Chapter Three was accepted for publication in *The Canadian Journal of Human Sexuality* and was co-authored by Ms. Sofija Lavrinsek and Dr. Dawson who provided manuscript feedback. Ms. Lavrinsek was also involved in data preparation and Dr. Dawson provided statistical consultation. Chapter Four is published in *The Journal of Sexual Medicine*. Chapter Five consists of a manuscript that is under review with *Archives of Sexual Behavior*. The manuscript was co-authored by Dr. Kelly Suschinsky, Ms. Lavrinsek, and Dr. Meredith Chivers who provided manuscript feedback. Dr. Suschinsky also consulted on data and result interpretation, and she and Dr. Chivers provided conceptual assistance. Ms. Lavrinsek was involved in data collection. Dr. Jonathan Huber is acknowledged for providing consultation on anatomy and participant inclusion criteria.

Chapter Two:

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Chapter Three:

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Chapter Four:

Sawatsky, M. L., & Lalumière, M. L. (2020). Effect of a condom cover on vaginal photoplethysmographic responses. *The Journal of Sexual Medicine, 17*, 702–715. doi:10.1016/j.jsxm.2019.12.021

Chapter Five:

Sawatsky, M. L., Suschinsky, K. D., Lavrinsek, S., Chivers, M. L., & Lalumière, M. L. (2020). Can the vaginal photoplethysmograph and its associated methodology be used to assess anal vasocongestion in women and men? Manuscript under review with *Archives of Sexual Behavior*.

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To my parents who instilled in me a curiosity about the world, a value in learning, and a desire to meaningfully contribute to the lives of others, I cannot thank you enough. Your unwavering support and belief in my success have carried me through my academic journey. To my Ottawa chosen family, your encouragement and support have extended well-beyond academics. Our sharing of ideas and experiences has shaped me in immeasurable ways.

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CHAPTER 1

General Introduction

Sexual psychophysiology involves the application of psychophysiological methods to the study of sexual response, with an emphasis on the interactions between physiology and psychology (Janssen, 2002). The human sexual response can consist of a complex interplay of physiological, cognitive, affective, and behavioural processes and experiences that occur in response to an internal (e.g., fantasy) or an external (e.g., audiovisual films) sexual stimulus (Chivers, 2005; Laan & Everaerd, 1995). Sexual psychophysiological methods have been applied to a wide array of research topics, including: models of sexual response (e.g., Janssen, Everaerd, Spiering, & Janssen, 2000; Masters & Johnson, 1966); impact of learning, conditioning, and habituation on sexual responsivity (e.g., Dawson, Lalumière, Allen, Vasey, & Suschinsky, 2013); sexual orientation, preferences, and interests (e.g., Chivers, Bouchard, & Timmers, 2015; Lalumière, Babchishin, & Ebsworth, 2018); sex and gender differences in sexual response patterns (e.g., Chivers, Rieger, Latty, & Bailey, 2004; Suschinsky, Lalumière, & Chivers, 2009); comparison across different measures of response (e.g., Bouchard, Chivers, & Pukall, 2017; Dawson, Sawatsky, & Lalumière, 2015); sexual offending and paraphilias (e.g., Blanchard, Klassen, Dickey, Kuban, & Blak, 2001; Lalumière, Quinsey, Harris, Rice, & Trautrimas, 2003); and sexual dysfunction and treatment efficacy (e.g., Brotto, Chivers, Millman, & Albert, 2016; Cherner & Reissing, 2013).

Early reports on the study of sexual response date back to the late 1800s and were primarily focussed on the physiological determinants of sexual arousal (Mendelsohn, 1896, as cited in Janssen, 2002). In the early-1900s, Van de Velde (1926) and Dickinson (1933) initiated the systematic study and documentation of the physiology of sexual response. In his book *Human Sex Anatomy* (1933), Dickinson wrote of the use of a glass tube to observe genital response in women, marking one of the first laboratory assessments of sexual arousal. In two pioneering scholarly works based on interviews with over 10,000 men and women, Kinsey

(Kinsey, Pomeroy, & Martin, 1948; Kinsey, Pomeroy, Martin, & Gebhard, 1953) reported on the physiological changes that accompany sexual behaviour. The Kinsey reports also drew attention to the psychological aspects of sexual arousal, with a focus on learning and conditioning, and to differences and similarities between men and women. Kinsey paved the way for Masters and Johnson (1956, 1966) whose foundational work spearheaded the modern laboratory approach to the study of human sexuality. Masters and Johnson primarily used direct observation (e.g., cameras), but also introduced many psychophysiological methods (e.g., a speculum to measure vaginal expansion, an electrode to measure vaginal pH) to examine genital changes during sexual arousal, thus providing impetus for further development of measures of genital responses. Even today, much of our understanding of the physiological events that characterize the sexual response can be credited to Masters and Johnson.

The Genital Response

Male Genital Response

The penile erection is a hemodynamic response involving three cylindrical erectile bodies—two corpora cavernosa and one corpus spongiosum—and the tunica albuginea, a sheath of elastic fibres that envelops the corpora cavernosa (Janssen & Prause, 2016; Levin & Riley, 2007; Riley, 2004). The corpora cavernosa have a purely erectile function. The corpus spongiosum contains the urethra, which provides the conduit for urination and ejaculation. The erectile bodies of the three corpora consist of multiple interconnected sponge-like cavernosal spaces, cavernous smooth muscle, and a fibro-elastic framework (Levin & Riley, 2007; Riley, 2004). In response to an effective sexual stimulus, the cavernous muscle relaxes and arterial dilation occurs. Increased blood flow into the cavernosal spaces produces an expansion of the erectile tissues. Expansion leads to a simultaneous compression of the veins against the tunica albuginea, which prevents blood outflow. As the erectile tissues engorge with blood (i.e.,

vasocongestion), penile tumescence and rigidity increase (Janssen & Prause, 2016; Levin & Riley, 2007; Riley, 2004). During ejaculation, secretions from the prostate, Cowper's gland, and seminal vesicles (containing spermatozoa) are propelled through the urethra by the rhythmic contractions of pelvic floor muscles, mainly the bulbocavernosus and ischiocavernosus muscles (Levin & Riley, 2007; Riley, 2004).

Female Genital Response

Genital changes associated with female sexual arousal include vaginal vasocongestion, vulvar engorgement, genital lubrication, vaginal and introital dilation, and clitoral tumescence (Levin, 2003; Levin & Riley, 2007; Masters & Johnson, 1966; Riley 2004). The vaginal canal is lined by a squamous epithelium and is surrounded by two layers of smooth muscle (Levin, 1992; Levin & Riley, 2007). In response to sexual stimulation, there is an increase in vasocongestion in the vaginal epithelium (i.e., the tissues that surround the vaginal canal) that results from increased arterial blood flow and venous vasoconstriction (Graziottin & Giraldi, 2006; Levin, 2004). Vaginal vasocongestion assessed with vaginal photoplethysmography increases within seconds of the presentation of an audiovisual sexual stimulus (Laan & Everaerd, 1995; Laan & Janssen, 2007; Suschinsky, 2012).

The increase in hydrostatic pressure within the vaginal capillaries forces plasma transudate into the interstitial space around the blood vessels (Graziottin & Giraldi, 2006; Levin, 1992; Levin, 2003; Levin & Riley, 2007). As the interstitial space fills, the transudate permeates through the intercellular channels of the epithelium, onto the surface of the vaginal canal. The lubricative transudate initially appears as sweat-like droplets on the surface of the vaginal epithelium (Masters, 1959). These tiny droplets of fluid eventually coalesce to form a lubricative film that covers the vaginal wall (Graziottin & Giraldi, 2006; Levin, 2003) and is visible within 10 to 30 seconds of sexual stimulation (Masters & Johnson, 1966). The introitus and vulvar

structures become lubricated as fluid leaks from the vagina (Levin, 2003). Small amounts of lubrication are also supplied by the Bartholin's glands, located bilaterally at the introitus (Berman & Bassuk, 2002; Janssen & Prause, 2016), and there is evidence that the labia produce some lubrication in a process similar to that of the vagina (Levin, 2003; Riley & Riley, 1983). Genital lubrication facilitates vaginal penetration, reducing the likelihood of genital pain, injury, or infection caused by sexual activity (Levin, 2003).

The clitoral structure is complex, with external (visible) components (e.g., glans or head) and internal components (e.g., crura or legs) that extend around the vagina and urethra to a length of 7 to 13 cm (Graziottin, & Gambini, 2015; Graziottin & Giraldi, 2006; Levin & Riley, 2007; Riley 2004). The clitoris contains erectile tissue and is considered homologous to the penis (Graziottin, & Gambini, 2015; Levin, 1992). Specifically, the vestibular bulbs of the crura appear homologous to the corpus spongiosum in men (Janssen & Prause, 2016). The clitoral body also consists of two corpora cavernosa. Upon sexual arousal, the clitoral structure engorges with blood, but does not become as rigid as the penis because there is no subalbugineal layer to constrict venous outflow (Graziottin, & Gambini, 2015; Janssen & Prause, 2016). According to Riley (2004), tumescence of the clitoral structure (including the crura) contributes to cushioning, which functions to minimize the risk of injury to the female genital tract during intercourse. On cessation of the sexual arousal, vaginal vasocongestion dissipates and lubrication is reabsorbed until the vagina returns to its basal (sexually unstimulated) moistness (Graziottin, & Gambini, 2015; Levin, 2003).

Models of Sexual Response

Based on their observational research, Masters and Johnson (1966) developed a highly influential model of sexual response that comprises four distinct phases: excitement, plateau, orgasm, and resolution. The Masters and Johnson model was particularly focused on genital and

extragenital physiological responses. Kaplan (1977) modified the Masters and Johnson model to include an initial stage of sexual desire, highlighting a psychological component of sexual arousal. Basson (2000) further expanded this concept by proposing that the manifestation of sexual desire, and the motivational factors that trigger it, may be unique among women (reviewed by Chivers & Brotto, 2017). Several other models of sexual arousal have been developed (e.g., dual-control model; Bancroft & Janssen, 2000). A unifying feature of modern models of sexual response is the inclusion of both psychological (cognitive, affective) and physiological features, and their complex interactions.

The information processing model (IPM) of sexual response is widely cited in current sexual psychophysiological research (Geer, Lapour, & Jackson, 1993; Janssen et al., 2000). According to this model, there are both automatic (unconscious) and controlled (conscious) cognitive processes that differentially impact the physiological and affective components of sexual arousal. In the initial processing stage, a cue that automatically evokes sexual meaning in memory is appraised as sexual. The detection of a sexually relevant cue triggers the attentional system and reflexively activates the genital response. According to the IPM, subsequent conscious processing of the sexual cue (and possibly the awareness of the initial genital response) is responsible for the self-reported feelings or experience of sexual arousal and the proliferation of the sexual response.

The notion that different components of the sexual response can be impacted by different mechanisms is consistent with findings from psychophysiological research showing that genital and self-reported sexual response are not necessarily highly associated (i.e., concordant). On average, the concordance between genital response and self-reported sexual arousal is stronger in men (r = .66) than in women (r = .26; meta-analysis by Chivers, Seto, Lalumière, Laan, & Grimbos, 2010). There is also substantial individual variation in sexual concordance estimates,

particularly among women (see Chivers & Brotto, 2017)—a finding that will be discussed in more detail below. Variation in the degree of association between different aspects of the sexual response highlights the importance of integrating self-report and physiological measures in sexual psychophysiological research.

Psychophysiological Measures

Self-Report Measures

In psychophysiology studies, self-reported sexual arousal is typically assessed using discrete and/or continuous indices of sexual arousal (Chivers, Suschinsky, Timmers, & Bossio, 2014; Huberman, Suschinsky, Lalumière, & Chivers, 2013). With discrete methods, participants rate aspects of sexual arousal at select time points, such as immediately following the presentation of a sexual stimulus. For instance, a participant may be asked to rate their overall feelings of sexual arousal (e.g., "How sexually aroused did the video make you feel?") or their perception of genital response (e.g., "How sexually aroused do your genitals feel?") according a Likert-type rating scale (e.g., 0–9). Post-stimulus questions can also be used to solicit information about specific genital sensations (e.g., throbbing), autonomic responses (e.g., increased heart rate), affective reactions (e.g., excited), or cognitive states (e.g., curious; e.g., Heiman & Rowland, 1983, Laan, Everaerd, & Evers, 1995; Suschinsky et al., 2009). Discrete questions may also be asked prior to a stimulus presentation to facilitate the calculation of a change score between pre- and post-stimulus ratings, which accounts for variation in baseline sexual arousal. Advantages of discrete indices include minimized distraction during a stimulus presentation and the option to query multiple dimensions of sexual arousal. A disadvantage of some discrete indices is the reliance on retrospective report, which can be vulnerable to recall biases.

In response to criticism regarding the accuracy of recall-based discrete indices, techniques

for continuous assessment of real-time changes in self-reported sexual arousal were developed (Wincze, Hoon, & Hoon, 1977). With continuous indices of sexual arousal, participants may be instructed to rate their sexual arousal (e.g., "overall feelings of sexual arousal") or genital sensations (e.g., vaginal wetness) throughout the entire stimulus duration. To do so, participants indicate increases and decreases in sexual arousal using a lever, mouse, or keypad (e.g., Chivers & Bailey, 2005; Laan, Everaerd, Van der Velde, & Geer, 1995; Suschinsky et al., 2009). For instance, participants may be asked to indicate changes in overall sexual arousal by pressing buttons on a keypad that correspond to the raising or lowering of a visual representation of a bar displayed on the television monitor (e.g., Suschinsky et al., 2009). Change scores can be calculated by subtracting the level of arousal at the onset of the stimulus from the mean or peak of the whole stimulus. Continuous and discrete measures of sexual arousal tend to be highly correlated in men and women (Huberman et al., 2013; Kukkonen et al., 2010; Rellini et al., 2005).

Self-report measures can be prone to bias (McCallum & Peterson, 2012). As discussed by Huberman et al. (2013), sexuality research may be particularly susceptible to socially desirable responding and impression management biases given that sexual attitudes are highly influenced by societal values and norms (Agocha, Asencio, & Decena, 2018). Stereotypes regarding traditional gender roles and sexual norms suggest that women may under-report sexual arousal. In two studies, Huberman et al. (2013) examined the relationship between impression management and discrete and continuous methods to assess self-reported sexual arousal in women. Based on their results, Huberman et al. (2013) recommend the use of continuous measurement or the calculation of pre-/post-stimulus change scores (rather than relying solely on post-stimulus ratings) to reduce impression management bias. Relative to self-report, genital responses are more difficult to manipulate (purposefully or not) and are generally considered to

be a more objective measure of sexual arousal (Chivers, Suschinsky, et al., 2014). Of course, objective does not equate to truer or more accurate; both genital and self-report indicators are meaningful dimensions of the sexual response (Chivers, Suschinsky, et al., 2014; Hatch, 1979).

Genital Response Measures

According to Masters and Johnson (1966; Masters, 1959), vasocongestion is the primary physiological response to sexual stimulation and is the most reliable indicator of sexual arousal in men and women. In light of this assertion, it is perhaps not surprising that the majority of physiological measures of sexual response assess an aspect of genital vasocongestion. The emphasis on measuring genital response to assess physiological sexual arousal was underscored by Zuckerman (1971) who concluded that such non-genital measures as heart rate, respiration rate, and pupil dilation were not specific to sexual arousal. The most widely used instruments to quantify genital response are the penile plethysmograph and the vaginal photoplethysmograph, respectively, but others continue to be developed, each with their own advantages and limitations (for reviews of female measures see; Kukkonen, 2014, 2015; Woodard & Diamond, 2009; for reviews of male and female measures see Chivers, Suschinsky, et al., 2014; Janssen, 2002).

Men. In 1963, Freund introduced the penile plethysmograph (PPG)—the first device capable of continuous measurement of genital response. Two types of PPG are used today—circumferential or volumetric—although the former is the most popular due to its ease of use and low cost. Circumferential PPG (e.g., Bancroft, Jones, & Pullan, 1966; Lalumière et al., 2003; Sakheim, Barlow, Beck, & Abrahamson, 1985) involves a mercury or indium-gallium-in-rubber strain gauge that is placed around the mid-shaft of the penis to assess changes in penile tumescence. Volumetric PPG (e.g., Freund, 1963; Freund, Watson, & Rienzo, 1989) involves a cylinder placed over the penis to assess changes in air displacement caused by erection. Measurements from circumferential and volumetric PPG are highly correlated (Kuban, Barbaree,

& Blanchard, 1999). Both devices have demonstrated good specificity and sensitivity as measures of genital arousal in men (e.g., Kuban et al., 1999) and show strong concordance with self-reported sexual arousal (e.g., Chivers et al., 2010). A limitation of PPG is that does not capture other penile changes that occur during an erection (e.g., angle, rigidity).

Measures of genital temperature have also been applied to the assessment of male sexual response (e.g., Huberman & Chivers, 2015; Kukkonen, Binik, Amsel, & Carrier, 2007; Kukkonen et al., 2010; Webster & Hammer, 1983). Surface thermistors (attached to the penis) or thermal imaging cameras (thermography) can be used to quantify genital temperature as an indirect measure of vasocongestion. Increases in genital temperature are thought to reflect greater vasocongestion and sexual arousal. Indeed, temperature change positively correlates with change in penile circumference assessed with PPG (Huberman & Chivers, 2015; Webster & Hammer, 1983). Thermography, the more popular of the two methods, detects and records the emission of infrared energy as skin temperature increases and has demonstrated good psychometric properties (reviewed by Tavares et al., 2018).

Laser Doppler imaging (LDI) has only recently been applied to men and the initial results demonstrate its validity as a measure of male genital response (Bossio, Singh, & Pukall, 2018). LDI involves a low-power laser beam that interacts with moving blood cells immediately below the skin surface. The speed of the moving blood produces a frequency change in the light, which is converted into a "flux" unit of measurement. A unique feature of LDI is that it is a direct measure of blood flow, in real time. When presented with vignettes describing sexual psychophysiological experiments and queried about the degree comfort at the prospect of participating, men reported greater comfort with thermography studies compared to those employing PPG and LDI (Huberman et al., 2019).

Women. In the mid-1970, Geer and colleagues (Geer, Morokoff, & Greenwood, 1974;

Sintchak & Geer, 1975) first documented the use of a vaginal photoplethysmograph (VPP) to quantify hemodynamic changes in the vaginal epithelium. In his brief report on the genesis of the VPP, Geer (2005) reflected that he and his colleagues were motivated by the dearth of instruments to assess women's physiological sexual responses and were inspired by research employing plethysmography to study fear (e.g., Sokolov, 1960). Independently, another group of researchers published a paper describing the use of a photoplethysmographic device to investigate vascular changes as a function of menstrual cycle phase (Palti & Bercovici, 1968). Today, the VPP remains the most commonly used measure of the female genital response.

The current VPP involves a clear acrylic tampon-sized cylindrical probe that contains an infrared light emitting diode (LED) and a phototransistor that detects backscattered light as an estimate of vasocongestion (Hoon, Wincze, & Hoon, 1976). Emitted light diffuses through the capillaries and circulating blood in the tissues of the vaginal wall. When the vaginal tissues engorge with blood, they become less transparent, which results in greater light reflectance from the tissues to the light detector. The amount of backscattered light is, therefore, thought to be contingent on the degree of vaginal vasocongestion. The VPP signal is filtered into two components. The alternating current (AC) component is referred to as vaginal pulse amplitude (VPA) and is believed to represent the phasic changes in vasocongestion associated with each heartbeat (higher amplitudes indicate greater vasocongestion; Laan & Everaerd, 1995). The direct current (DC) reflects slow changes in blood pooling and is referred to as vaginal blood volume (VBV; Hatch 1979). Results from several studies show that VPP is a valid measure of genital response (Laan et al., 1995; Suschinsky et al., 2009) and that the AC signal has superior sensitivity and specificity as a measure of sexual response compared to the DC signal (e.g., Geer et al., 1974; Heiman, 1977; Laan et al., 1995; Osborne & Pollack, 1977).

There are several limitations of the VPP. For example, there exists no standardized

calibration procedure and the measurement scale is relative (not absolute); therefore, between-participant comparisons are not advised (Kukkonen, 2014, 2015; Prause & Janssen, 2005). Also, the VPP is an indirect, rather than direct, measure of vascular change. A major criticism is that although it is purported to be a measure of vaginal vasocongestion, several authors have pointed out that the mechanism is not well-understood (Laan & Everaerd, 1995; Levin, 1992; Levin & Wylie, 2008; Prause & Janssen, 2005). In light of these limitations, alternative measures have been developed and applied to the study of female genital responses.

Surface thermistors, typically attached to the labia minora (Henson & Rubin, 1978; Prause & Heiman, 2009), and thermography (Abramson, Perry, Seeley, Seeley, & Rothblatt, 1981) have been validated in women and have shown good psychometric properties (reviewed by Tavares et al., 2018). In response to sexual stimuli, temperature change assessed with thermistors (e.g., Henson & Rubin, 1978; Henson, Rubin, & Henson, 1979) and thermography (Huberman & Chivers, 2015; Kukkonen et al., 2007, 2010) is consistently positively correlated with VPA assessed with VPP. Temperature change in women is more strongly positively associated with self-reported sexual arousal than is VPA (Chivers et al., 2010). An important advantage of temperature assessment is that the units of measurement (degrees Celsius) are easily interpretable and on an absolute scale, which facilitates comparisons between participants and groups (Kukkonen et al., 2007; Tavares et al., 2018).

LDI is a valid measure of genital response in women that has shown specificity for sexual response (Waxman & Pukall, 2009) and good test-retest reliability with testing sessions at least two weeks apart (Styles, MacLean, Reid, & Sultana, 2006). LDI can be used to measure subcutaneous blood flow of the whole vulvar area or specific structures (e.g., labia, fourchette, clitoral hood; Bouchard, Dawson, Shelley, & Pukall, 2019; Bouchard et al., 2017; Boyer, Pukall, & Chamberlain, 2013; Boyer, Bouchard, & Pukall, 2019; Styles et al., 2006; Waxman & Pukall,

2009). Sexual responses measured with LDI are positively correlated with VPA (e.g., Boyer et al., 2019) and are more strongly correlated with self-reported sexual arousal than is VPA (Bouchard et al., 2017). In terms of participant comfort, Huberman et al. (2019) found that women reported a similar degree of comfort at the prospect of participating in VPP and thermography studies, and these comfort levels were higher than for studies involving a labial thermistor or LDI.

Other, less commonly used measures of female genital response have been designed and tested. The clitoral photoplethysmograph, a measure of clitoral blood volume or clitoral pulse amplitude, has been validated as a measure of sexual response in women (Gerritsen et al., 2009; Mechelmans, Sachtler, von Wiegand, Goodrich, Heiman, & Janssen, 2017; Suschinsky, Dawson, & Chivers, 2020; Suschinsky, Shelley, Gerritsen, Tuiten, & Chivers, 2015). In one study, labial photoplethysmography demonstrated responses specificity to sexual stimuli and appeared to be less sensitive to movement artifacts than the VPP (Prause, Cerny, & Janssen, 2005). Responses assessed with clitoral and labial photoplethysmographs positively correlate with VPP (Gerritsen et al., 2009; Prause et al., 2005).

Early studies on the use of VPP inspired the development of a number of instruments to study genital responding in women and some have been used to compare sexual response patterns to those observed for men (e.g., thermography; Huberman & Chivers, 2015). Intriguing findings have emerged from this research. As mentioned, men exhibit stronger concordance between genital and self-reported sexual response than women, on average. A somewhat related finding concerns the degree of *cue-specificity* (Lalumière, 2017) that men and women exhibit in response to sexual stimuli.

Genital Response Cue-Specificity

Cue-Specificity in Men

Men's sexual responses, including their genital responses and self-reported feelings of sexual arousal, are highly dependent on specific cues in a sexual stimulus (e.g., Blanchard et al., 2001; Chivers & Bailey, 2005; Chivers et al., 2004; Rieger, Chivers, & Bailey, 2005; Rosenthal, Sylva, Safron, & Bailey, 2012; Sakheim, et al., 1985; Suschinsky et al., 2009). Cues may be related to characteristics of the sexual targets depicted in the stimulus (e.g., gender/sex, age) or aspects of the sexual encounter (e.g., sexual activity intensity, presence or absence of consent, depictions of violent or masochistic sex, relationship context; e.g., Chivers, Roy, Grimbos, Cantor, & Seto, 2014; Chivers, Seto, & Blanchard, 2007; Chivers & Timmers, 2012; Freund et al., 1989; Lykins et al., 2010; Suschinsky & Lalumière, 2011a, 2011b).[1] Large increases in penile response, assessed with PPG, are observed in response to sexual stimuli depicting preferred sexual targets (i.e., targets that correspond to self-reported sexual interests and attractions). For example, men who are gynephilic (i.e., sexually attracted to women) exhibit substantial penile responses to sexual stimuli depicting male–female or female–female oral and penetrative sex (i.e., vaginal penetration with a penis or a strap-on dildo, respectively) or female masturbation, and little (if any) response to stimuli depicting male–male penetrative sex (i.e., anal penetration) or male masturbation (e.g., Chivers & Bailey, 2005; Sakheim et al., 1985). The converse is observed for men who are androphilic (i.e., sexually attracted to men): They respond maximally to sexual stimuli involving men (e.g., Chivers et al., 2004, 2007; Sakheim et al., 1985). This pattern of responding, whereby different variations of sexual cues elicit different degrees of sexual arousal, is termed *cue-specificity* (Lalumière, 2017); thus, men's genital and

[1] It is acknowledged that a sexual cue does not exist in isolation. A sexual stimulus is an amalgamation of cues (e.g., gender, sex, sexual activity, relationship, memories) that are potentially sexually activating. Attempts to manipulate one cue, such as the sex (i.e., primary or secondary sex characteristics) of a sexual target depicted in a stimulus, may result in changes to related stimulus content, such as sexual activity types and gender roles.

self-reported sexual responses exhibit relatively high cue-specificity for gender/sex[2] cues.

The specificity of men's genital responses has been documented for other cues. For instance, men's penile responses vary according to the age of the sexual target: Gynephilic men respond substantial more to erotic audio-narratives involving adult women than young girls (Lykins et al., 2010). Men who have sexually offended against a child exhibit, as a group, stronger genital responses to sexual stimuli involving pubescent and pre-pubescent children compared to groups of male sex-offenders against adults or non-offenders (e.g., Blanchard et al., 2001; Quinsey, Steinman, Bergersen, & Holmes, 1975). Non-offending men exhibit much lower penile responses to audio-narratives depicting sexual violence and nonconsent compared to those depicting consensual, nonviolent sex (Suschinsky & Lalumière, 2011a, 2011b). The results from these studies suggest that for men, genital responses correspond to self-reported feelings of sexual arousal and are closely linked with sexual preferences and behaviour.

Cue-Specificity in Women

Gender/sex cues. Relative to men, women's genital responses demonstrate much lower cue-specificity and are more weakly associated with self-reported sexual responses (e.g., Bossio, Suschinsky, Puts, & Chivers, 2014; Chivers & Bailey, 2005; Chivers, Roy, et al., 2014; Chivers & Timmers, 2012; Chivers et al., 2004, 2007; Laan, Sonderman, & Janssen, 1996; Peterson, Janssen, & Laan, 2010; Suschinsky & Lalumière, 2011a, 2011b; Suschinsky et al., 2009). Women, on average, demonstrate a rapid increase in VPA when presented with male and/or female sexual stimuli depicting partnered sex or masturbation (e.g., Chivers et al., 2007). For androphilic women, the magnitude of genital response is very similar for male and female sexual cues and this has been replicated across a number of studies (e.g., Bossio et al., 2014; Chivers &

[2] The term gender/sex has been recommended in contexts when gender and sex cannot be disentangled (van Anders, 2015).

Bailey, 2005; Chivers & Timmers, 2012; Chivers et al., 2004, 2007; Suschinsky et al., 2009).

Gynephilic women consistently produce substantial increases in VPA to both male and female sexual stimuli (e.g., Chivers et al., 2004), but responses tend to be higher for preferred (i.e., female) sexual stimuli (e.g., Chivers et al., 2007; Rieger et al., 2015). Chivers et al. (2007) presented both masturbation and partnered sex film clips and found that gynephilic women demonstrated specificity for female sex, but only for the low-intensity masturbation stimuli (androphilic women demonstrated low gender/sex cue-specificity regardless of stimulus intensity). The authors posited that gender/sex-specificity did not emerge for the high-intensity partnered sex stimuli due to a ceiling effect, whereby VPA reached a threshold at which the intensity of sexual activity exceeded the effect of gender/sex cues. Chivers et al. (2015) replicated the sexual orientation difference in cue-specificity using two different stimulus modalities: Gynephilic women demonstrated specificity for female sexual films (VPA to nude exercise, masturbation, partnered sex stimuli were averaged; data partially overlapped with Chivers et al., 2007), and audio-narratives (manual stimulation performed by the participant on a woman), whereas exclusively androphilic women demonstrated low gender/sex cue-specificity for both stimulus modalities. Taken together, gynephilic women exhibit higher gender/sex cue-specificity relative to androphilic women (reviewed by Chivers, 2017; for exceptions see Peterson et al., 2010, and Pulverman et al., 2015, who found that both gynephilic and androphilic women demonstrated greater genital responses to male–female sex compared to female–female sex).

Some studies have included women with varying degrees of same- and other-gender/sex sexual attractions, rather than only comparing androphilic and gynephilic women (Bouchard, Timmers, & Chivers, 2015; Chivers et al., 2015; Rieger et al., 2015; Rieger, Savin-Williams, Chivers, & Bailey, 2016; Timmers, Bouchard, & Chivers, 2015). The results from these studies

suggest that the lack of response discrimination for gender/sex cues is characteristic of exclusively androphilic women. Chivers et al. (2015) included women across the range of Kinsey scale scores (Kinsey et al., 1948, 1953) and found that women with any degree of gynephilia, including women who were predominantly androphilic or androgynephilic (i.e., similar degree of sexual attraction to men and women), exhibited greater VPA in response to female versus male sexual films and audio-narratives. In two studies examining androgynephilic women (samples partially overlap with Chivers et al., 2015)—with androgynephilia defined according to multiple dimensions of sexual orientation (i.e., sexual or romantic attraction, sexual identity, sexual fantasy, or sexual behaviour)—VPA was consistently higher in response to female versus male sexual stimuli (Bouchard et al., 2015; Timmers et al., 2015). In a recent study, however, Suschinsky et al. (2020) did not replicate the Chivers et al. (2015) findings: Vaginal and clitoral responses demonstrated low gender/sex cue-specificity for both exclusively and predominantly androphilic women.

Notably, sexual orientation differences in the degree of gender/sex cue-specificity among women appear to emerge due to variation in the degree of genital responses to male sexual cues, whereas women of all sexual orientations more consistently respond to female sexual cues (Chivers et al., 2015; Rieger et al., 2015). To illustrate, Chivers et al. (2015) found that gender/sex sexual attraction predicted genital responses to male but not female sexual cues. In other words, a stronger degree of gynephilia was associated with weaker genital responses to male sexual stimuli, whereas response magnitudes to female sexual stimuli were more consistent across sexual orientation groups.

Although there appears to be a sexual orientation difference in genital response patterns among women, gynephilia does not eliminate the gender/sex difference in cue-specificity. In another study that included men and women across the spectrum of gender/sex attractions,

gynephilic women demonstrated higher gender/sex cue-specificity compared to androphilic women, but the degree of discrimination between male and female stimuli for gynephilic women was much smaller compared to men (Rieger et al., 2015). Women of all sexual orientations consistently produce substantial genital responses to both preferred and non-preferred gender/sex cues (relative to nonsexual stimuli)—a response pattern that is distinct from that of men (Chivers et al., 2007; Rieger et al., 2015).

Self-reported sexual arousal. In terms of self-reported sexual arousal, androphilic women often demonstrate cue-specificity, but not necessarily in the direction predicted by their sexual preferences and attractions: Male sexual stimuli may be rated as more (Bossio, Suschinsky, et al., 2014; Chivers & Timmers, 2012; Spape et al., 2014; Timmers, 2019) or less (e.g., Chivers et al., 2004, 2007; Suschinsky et al., 2009) sexually arousing than female sexual stimuli. When male–female partnered sex is included as a stimulus category, androphilic women often rate it as more sexually arousing than male–male or female–female sex (e.g., Chivers et al., 2004, 2007; Chivers & Bailey, 2005; Suschinsky, Bossio, & Chivers, 2014; Suschinsky et al., 2009; Chapter Two). For gynephilic women, self-reported sexual arousal also demonstrates specificity for female sexual stimuli and is, therefore, more strongly associated with sexual attractions (e.g., Suschinsky et al., 2017). Androgynephilic women also report higher sexual arousal to female sexual stimuli (Bouchard et al., 2015; Timmers et al., 2015).

Sexual concordance. A corollary of low cue-specificity for genital response is the relatively low concordance between women's genital responses and self-reported sexual arousal, on average (Chivers et al., 2010). Low sexual concordance in women is typically a function of minimal or absent feelings of sexual arousal in the presence of a genital response; the reverse pattern is not typically observed (Laan & Everaerd, 1995). There is also substantial variation in sexual concordance among women and this has been observed using a variety of measures of

genital response (e.g., Bouchard et al., 2017; Kukkonen, Binik, Amsel, & Carrier, 2010; Rellini, McCall, Randall, & Meston, 2005) and self-reported sexual arousal (e.g., Suschinsky, Dawson, & Chivers, 2017). For instance, Kukkonen et al. (2010) observed that the concordance between labial temperature and continuously rated sexual arousal in women ranged from $r = –.36$ to $r = .95$ (concordance scores for men ranged from $r = .11$ to $r = .94$). Variation in sexual concordance among women has been associated with individual difference factors, such as cognitive sexual schemas (Clifton, Seehuus, & Rellini, 2015), degree of sexual excitation and inhibition (Clifton et al., 2015), sexual functioning (Meston, Rellini, & McCall, 2010; Suschinsky et al., 2019; reviewed by Chivers & Brotto, 2017), and degree of sexual attraction to men and/or women (Suschinsky et al., 2017). Suschinsky et al. (2017) included women across the spectrum of gender/sex sexual attractions and found that women with any degree of gynephilia exhibited stronger sexual concordance compared to women with exclusive androphilic sexual attractions. Rieger et al. (2015) also reported stronger correspondence between genital and self-reported sexual arousal in gynephilic women compared to androphilic women, and the degree of correspondence for gynephilic women was weaker than for androphilic or gynephilic men.

Other cues. Relatively low genital response cue-specificity among androphilic women has been observed for sexual stimuli that vary in the presence of consent and violence. Androphilic women (but not gynephilic men) produce genital responses, assessed with VPP, to audio depictions of nonconsensual, violent sex that are very similar to their responses to consensual, nonviolent sex (Suschinsky & Lalumière, 2011a, 2011b). Genital responses to nonconsensual, violent sex are observed even when androphilic women rate these stimulus categories as unpleasant, anxiety-provoking, and sexually non-arousing (Suschinsky & Lalumière, 2011a, 2011b).

In one study (Chivers, Roy, et al., 2014), androphilic women who reported only

conventional sexual interests demonstrated substantial increases in VPA to audio depictions of both conventional and masochistic sex (relative to a neutral nonsexual stimulus) and this was observed even though masochistic sex did not elicit self-reported sexual arousal. Genital responses to masochistic sex were, however, not as elevated as responses to conventional sex; thus, women with conventional sexual interests demonstrated cue-specificity for the stimulus category (conventional sex) that matched their sexual activity preferences. Consistent with previous research, VPA did not discriminate between male and female sexual stimuli. For the gynephilic men with conventional sexual interests, a different pattern was observed: Genital responses were observed only in response to stimuli depicting conventional sex and responses to masochistic sex were comparable to the neutral stimulus. These results highlight the sensitivity of women's genital responses to sexual cues, even those that are not preferred, and also suggest that other aspects of the sexual encounter, apart from the gender/sex of the sexual targets, can influence the magnitude of genital response.

Other cues related to the sexual context produce variation in response magnitude. A contextual feature that impacts the degree of genital responsivity is the intensity of sexual activities depicted. Chivers et al. (2007) presented androphilic and gynephilic men and women with sexual stimuli that increased in erotic intensity from nude exercise (i.e., no sexual activity), to solitary masturbation, to penetrative intercourse, and found that VPA increased with the intensity of the sexual activities portrayed. The effect of sexual activity intensity has been replicated in some (Suschinsky et al., 2009; Suschinsky et al., 2014), but not all (Bouchard et al., 2017; Chapter Two) studies.

Another contextual cue that influences women's genital response magnitude is the relationship context between men and women featured in sexual narratives. Chivers and Timmers (2012) found that VPA for androphilic women was higher in response to depictions of

sexual interactions with friends than to sexual interactions with a stranger or in a long-term relationship context, and these patterns were consistent for both male and female sexual narratives. These results highlight the influence of contextual cues on genital response patterns and suggest that some contextual elements may be more relevant to women's genital response than the gender/sex of the sexual targets.

Spape et al. (2014) presented women with images of genitals in which contextual information was limited. Cue-specificity for male stimuli was observed for androphilic women: VPA in response to images of erect penises was greater than to images of exposed vulvas. The authors postulated that cue-specificity for gender/sex cues can emerge when contextual cues are minimized. To the extent that an erect penis is a more obvious and intense sexual cue than an engorged vulva, the degree of cue-specificity for gender/sex cues in this study may have been influenced by erotic intensity. Recent research has replicated the Spape et al. (2014) finding that cue-specificity can be observed when presenting still images with limited contextual information: Timmers (2019) found greater VPA among androphilic women in response to images portraying attractive and unattractive men compared to women. It was also the case that attractive and unattractive female nude images elicited greater genital responses than neutral images—an effect not observed among the gynephilic men whose genital responses to male nude images were comparable to that of neutral images. Taken together, the results suggest that contextual cues present in a sexual stimulus are important determinants of genital response magnitude in androphilic women and may influence patterns of genital response to male and female sexual cues (discussed by Timmers, 2019).

Although genital response magnitude in women is sensitive to variations in some contextual cues, substantial vaginal responses can be elicited by nonpreferred sexual stimuli that are minimally sexually arousing, and this is observed for women across the spectrum of

gender/sex sexual attractions (e.g., Chivers et al., 2004, 2007). This pattern of response is distinct from that of men whose sexual responses more strongly differentiate between preferred and nonpreferred stimuli, and more strongly relate to sexual attractions (e.g., Rieger et al., 2015). Because women's genital responses can be elicited by almost any sexual cue regardless of sexual preferences or the subjective appraisal of the stimulus, women's genital responses have been characterized as automatic (e.g., Chivers, 2005; Laan, 1994; Laan & Evaraerd, 1995; Laan, Everaerd, Van Aanhold, & Rebel, 1993; Suschinsky et al., 2009). The automaticity of women's genital responses to any sexual cue has led researchers to hypothesize about the function of vaginal response patterns.

Hypotheses for Low Cue-Specificity in Women

In her review of sexual response specificity in women, Chivers (2017) consolidated a number of proximate (causation in terms of immediate physiological or environmental mechanisms) and ultimate (causation in terms of evolutionary function or fitness consequences) explanations and presented ten hypotheses, which she outlined and evaluated. Since its publication, additional explanations for gender/sex differences in sexual arousal patterns have been proposed (e.g., Diamond, 2017; Luoto & Rantala, 2017). Consistent with the IPM of sexual response (Geer et al., 1993; Janssen et al., 2000), some hypotheses pertain to women's attention and cognitive processing of nonpreferred sexual stimuli. For instance, the sexual objectification of women's bodies that is common in the media (Fredrickson & Roberts, 1997) may contribute to the formation of learned sexual associations that activate a sexual response to sexual stimuli depicting women, even for androphilic women (a finding that does not support this hypothesis is that androphilic men do not sexually respond to female sexual stimuli; reviewed by Chivers, 2017). It has also been proposed that genital responses to female sexual cues may result from identification with the female actor experiencing sexual pleasure (Money & Ehrhardt, 1972;

reviewed by Bossio, Spape, Lykins, & Chivers, 2014; Chivers, 2017). Attentional focus motivated by intrasexual competition has also been discussed (e.g., Maner, Gailliot, Rouby, & Miller, 2007; reviewed by Chivers, 2017). Another explanation is that the capacity for response differential may be smaller in women compared to men, resulting in indistinguishable genital responses to preferred and nonpreferred sexual stimuli (Sylva et al., 2013); however, as Chivers (2017) points out, amplifying vaginal response using vibrotactile stimulation does not appear to impact the degree of response discrimination (Peterson et al., 2010).

Some hypotheses are relevant to within-gender/sex variability in cue-specificity. It has been proposed that specificity for gender cues represents a male-typical pattern of response that is consistent with gynephilic women's tendency to demonstrate more masculine traits and nonsexual behaviour compared to androphilic women (e.g., gestures and movements, speech patterns, occupational preferences; e.g., Lippa, 2008; reviewed by Bailey et al., 2016). Male-typical sexual arousal and masculinized behaviour in women have been associated with elevated prenatal androgen exposure (Auyeung et al., 2009; Meyer-Bahlburg, Dolezal, Baker, & New, 2008). In two studies, Rieger et al. (2016) tested this explanation and found no relationship between male-typical nonsexual behaviours in women and the specificity of vaginal responding to male and female sexual stimuli. In her review, Chivers (2017) highlighted avenues for further testing these and other hypotheses.

One of the most well cited hypotheses for low cue-specificity in women is the *preparation hypothesis*, coined by Suschinsky and Lalumière (2011a, 2011b; for a critical review of relevant literature see Lalumière, Sawatsky, Dawson, & Suschinsky, 2020). The preparation hypothesis is a functional (ultimate) explanation that proposes that the automatic and indiscriminate nature of women's genital responses serves a protective function (Chivers, 2005; Laan, 1994; Laan & Janssen, 2007; Suschinsky et al., 2009). According to the preparation

hypothesis, selection may have favoured women who automatically produced a genital response to any sexual cue because of the high costs associated with not being lubricated should vaginal penetration occur (i.e., genital injury, infection; e.g., Chivers, 2005; Chivers & Bailey, 2005). It would have been adaptive for this reflexive response to occur independent of feelings of sexual arousal given the fitness benefits associated with producing lubrication even in the absence of feelings of sexual arousal or appeal, such as in the context of nonconsensual sex.[3]

In support of the preparation hypothesis, Suschinsky and Lalumière (2011a, 2011b) found that androphilic women demonstrated increases in VPA in response to scenarios describing violence and nonconsensual sex that were similar in magnitude to scenarios describing consensual nonviolent sex. Vaginal responses to nonconsensual violent sex were observed even though these stimuli were rated to be unpleasant, anxiety-provoking, and not sexually arousing. For men, increases in genital and self-report sexual responses were specific to consensual nonviolent sex. Substantial increases in VPA to sexually threatening stimuli in the absence of self-reported sexual arousal have been reported by other researchers (Laan et al., 1995; Suschinsky et al., 2009). The sensitivity of women's genital responses to sexual cues is also demonstrated by research showing that films portraying mating bonobos elicit increases in genital response for women (but not men) despite no increases in self-reported sexual arousal (Chivers & Bailey, 2005). These findings are consistent with predictions from the preparation hypothesis, but all pertain to vaginal vasocongestion assessed using VPP. A perhaps more optimal test of the preparation hypothesis would be to directly assess the cue-specificity of genital lubrication.

Quantifying Lubrication as a Sexual Response

[3] According to Bancroft and Graham (2011), a proximate mechanism explaining indiscriminate genital response in women is to facilitate painless vaginal penetration.

The first attempts to quantify lubrication and to elucidate its constituents date back to the late 1950s (e.g., Perl & Shimozato, 1959). Methods used to measure change in vaginal lubrication in response to sexual stimulation included a weighed tampon or filter paper, and evaporimeters (Preti et al., 1979; Riley & Riley, 1983; Wagner, 1979; Wagner & Levin, 1978). These methods tended to be cumbersome and invasive and did not allow for multiple measurements within a single experimental session. For several decades, there were virtually no empirical studies on vaginal lubrication. In 2003, Carranza-Lira et al. assessed vaginal wetness using a pH test-strip placed at the introitus to test the efficacy of a hormonal treatment. This study inspired Dawson, Sawatsky, and Lalumière (2015) to design and test a measure of genital lubrication, called a litmus test strip (LTS), that could be used repeatedly within a single experimental session.

The LTS, which was self-administered by participants, consisted of a strip of litmus paper attached to a plastic applicator. Immediately after a stimulus presentation, women placed the tip of the LTS applicator at the introitus for 60 s. Vaginal fluid produced a colour change on the litmus paper as it was absorbed up the length of the LTS. The length of colour change was recorded (in mm) as an index of genital lubrication. In the Dawson et al. (2015) study, the genital responses of androphilic women were measured with LTS for half of the testing sessions, and with VPP for the other half. Participants rated their sexual arousal and their perceived genital response post-stimulus.

Dawson et al. (2015) found that both VPA and lubrication responses were greater for sexual compared to nonsexual films (d = .85 and .53, respectively). There was no correlation between VPA and lubrication, which was unexpected given that vaginal vasocongestion is thought to be a precursor to lubrication (Levin, 2003). Lubrication was correlated with self-reported sexual arousal and perceived genital response (r = .61 and .51, respectively), while VPA

was not (r = .001 and r = .06, respectively). These results suggest that the LTS device can be used to quantify genital lubrication to sexual stimuli in a repeated measures experimental design and, therefore, can be used to examine the cue-specificity of genital lubrication as a test of the preparation hypothesis. Although low cue-specificity in women has been well replicated using VPP, there have been few attempts to assess cue-specificity for gender/sex cues using alternative measures of genital response (for exceptions see Huberman & Chivers, 2015; Suschinsky et al., 2020).

Measurement Issues in Cue-Specificity Research

The majority of studies investigating cue-specificity (and sexual concordance) in men and women have assessed genital responses using PPG and VPP, respectively. Despite the widespread use of these instruments, methodological differences call into question the legitimacy of directly comparing their results. One obvious difference is that PPG and VPP do not measure changes in vasocongestion in the same anatomical region. Graziottin and Gambini (2015) describe how the capacity for change in genital vasocongestion is different for men and women due to differences in the arterial blood supply and circulatory systems of the male and female genitalia. Furthermore, each measure provides different data outputs: VPP records VPA in millivolts, and PPG measures penile circumference in millimeters or blood volume in milliliters. The observed gender/sex difference in cue-specificity may reflect the use of non-comparable measurement devices and scales, and methodologies that assess different aspects of physiological responding, rather than a true gender/sex difference in genital response patterns (Huberman & Chivers, 2015; Kukkonen, 2015; Kukkonen et al., 2007).

To examine whether gender/sex differences in cue-specificity are an artifact of differences in genital response measurement in men and women, Chivers et al. (2004) included a sample of transwomen who had undergone gender-affirming surgery to construct a neovagina,

and compared their genital responses to cisgender men and women. VPP was used to assess the genital responses of the transwomen (prior research demonstrated detectable blood flow in the neovagina; Schroder & Carroll, 1999). Similar to the male sample, the genital responses of the androphilic transwomen and gynephilic transwomen demonstrated gender/sex cue-specificity, with stronger VPA observed for preferred versus nonpreferred sexual stimuli (data were re-analyzed and replicated in Lawrence, Latty, Chivers, & Bailey, 2005).

The Chivers et al. (2004) results provide preliminary evidence that differences in patterns of genital response cue-specificity are not simply artifacts of the measurement devices because both cisgender women and transwomen exhibited different response patterns despite genital responses being measured by the same device (VPP). It is still the case, however, that different anatomical structures were assessed across the participant groups. Vascularisation of male and female genitalia are dissimilar—blood volume and inflow pressures are much greater for the penis than the female genitalia (Graziottin & Gambini, 2015). The neovagina, typically constructed from penile tissues, also has distinct vascularization compared to the natal vagina and the surrounding blood vessels may not be innervated to the same extent (summarized in Lawrence et al., 2005). This leaves open the possibility that differences in cue-specificity reflect anatomical differences rather than fundamentally distinct genital response patterns.

Another approach to examining the impact of measurement device on observed patterns of cue-specificity is to employ the same measurement device for cisgender men and women. Huberman and Chivers (2015) concurrently measured genital response with thermography and either VPP or PPG. Gynephilic men showed increases in genital temperature and circumference to only the female stimuli. For androphilic women, increases in genital temperature and VPA were observed in response to both male and female masturbation film clips. The gender/sex difference in cue-specificity was observed when comparing temperature changes of the labia

majora and penile shaft, as well as the clitoris and penile glans, which are homologous structures. Genital cue-specificity was not the only gender/sex difference found in this study, however: Women rated the male and female masturbation stimuli as equally sexually arousing, whereas men rated female masturbation as much more sexually arousing than male masturbation. It is unknown to what extent cue-specificity of genital temperature is affected by self-reported sexual arousal, but there is evidence that the concordance between genital and self-reported sexual arousal in women is stronger for thermography than VPP (Chivers et al., 2010). It is possible that the lack of differentiation in women's self-reported sexual arousal may have contributed to low cue-specificity observed with thermography.

To date, thermography is the only device that has been applied to both men and women to compare patterns of cue-specificity (Huberman & Chivers, 2015; Huberman, Dawson, & Chivers, 2017; but see Chapter Five). A disadvantage of using thermography to compare male and female genital response patterns is that different anatomical structures are assessed for men and women and there is no consensus as to which structures are appropriate to compare (if any). Even though the measurement output (degrees Celsius) of thermography is identical for men and women, only within-gender/sex comparisons are advised (Huberman & Chivers, 2015). This is because the capacity for change in vasocongestion, and therefore temperature, is larger for male compared to female genitalia, possibly due to differences in their proximity to the torso (Chivers, 2017) and differences in their hemodynamic demands (Graziottin & Gambini, 2015).

Ideally, to test whether the observed gender/sex differences in cue-specificity are true phenomena, the same measurement device would be administered at the identical anatomical site in men and women. Two groups of researchers (Bohlen & Held, 1979; Carmichael et al., 1987; Carmichael, Warburton, Dixen, & Davidson, 1994) used an anal probe containing a photoplethysmograph to measure changes in anal vasocongestion during sexual arousal. These

authors reported an increase in anal vasocongestion in both men and women in response to self-stimulation (masturbation). The anal photoplethysmograph (APG) has not been used in any known research studies since the Carmichael et al. (1994) report. If the validity of the anal photoplethysmograph can be established, it may be an optimal method to test gender/sex differences in cue-specificity, particularly given that the anatomy and physiology of the male and female anal canals appear to be quite similar (reviewed in Chapter Five).

Another factor that could contribute to the gender/sex difference in genital response patterns observed with the VPP and PPG could be that these devices assess different phases of the genital response (Chivers, 2017). Vasocongestion within the vaginal walls has been referred to as an initial, automatic genital response (e.g., Chivers, 2005; Laan & Everaerd, 1995) that occurs within seconds of a visual sexual stimulus (e.g., Laan & Janssen, 2007; Suschinsky, 2012) and peaks within approximately 20 s (Huberman et al., 2017). PPG assesses penile tumescence, which gradually increases over time, reaching its peak within approximately 230 s (Huberman et al., 2017). It is therefore possible that VPP and PPG assess different end-points of vasocongestion (Chivers, Suschinsky, et al., 2014). It may be more appropriate to compare penile tumescence with relatively later-occurring aspects of the female genital response. Consistent with the preparation hypothesis, indiscriminate vaginal responding may be a reflexive initial response whereas, according to the IPM (Janssen et al., 2002), further elaboration of the sexual stimulus can affect the maintenance of this response over time.

The time course of vaginal vasocongestion cue-specificity for gender/sex cues was investigated in two studies. Huberman and Chivers (2015) analyzed cue-specificity across five segments (120 s each) of 600 s audiovisual stimuli and found that low cue-specificity for VPA, genital temperature, and self-reported sexual arousal was consistent across time. Pulverman et al. (2015) examined the trajectory of VPA in response to 600 s films featuring male–male, female–

female, and male–female sex. For androphilic women, VPA continued to increase over time for the male–female and male–male sexual stimuli, whereas the initial increase in VPA to the female–female sexual stimulus was not maintained. Notably, VPA for gynephilic women also decreased over time in response to female–female sex, suggesting that the female–female sexual stimulus presented in this study may not have been sufficiently sexually arousing to sustain genital responding. The time course of continuous self-reported sexual arousal was not examined in this study (only discrete post-stimulus sexual arousal was assessed). Further studies are required to assess the time course of patterns of cue-specificity.

Dissertation Objectives

The overarching objective of the research program outlined in this dissertation is to add to the sexual psychophysiological literature on sexual response patterns by testing current hypotheses or explanations for the observed gender/sex difference in cue-specificity. To do so, two novel measures of sexual response were employed—LTS and APG—in addition to the more commonly used VPP and PPG. In Chapter Two, the LTS device was used to assess the cue-specificity of genital lubrication, for the first time, as a direct test of the preparation hypothesis. In Chapter Three, the time course of cue-specificity for vaginal vasocongestion, assessed with VPP, was investigated to determine whether low cue-specificity in androphilic women is maintained across the duration of relatively longer sexual stimuli (240 s) that produce discrimination in self-reported sexual arousal—a question that emerged based on the results of Chapter Two.[4] For a visual comparison with the female data, the Chapter Three appendix presents figures showing the response patterns of a small sample of gynephilic men whose genital responses were assessed with PPG.

Chapters Four and Five focused on testing methodology related to the APG to determine

[4] Chapters Two and Three used data from the same sample.

its potential for studying gender/sex differences in cue-specificity. In Chapter Four, a condom was placed over the VPP probe to determine if a probe cover would compromise vaginal photoplethysmographic data. The purpose of this study was to prepare for the APG validation study presented in Chapter Five, in which a VPP probe encased in a condom cover for sanitary purposes was inserted intra-anally as an APG. In Chapter Five, the APG was tested to determine whether it could specifically detect a sexual response, elicited by audiovisual sexual stimuli in a repeated measures design. A summary of the results reported in this dissertation is provided in Chapter Six, which also includes a discussion of implications and suggestions for future research.

References

Abramson, P. R., Perry, L. B., Seeley, T. T., Seeley, D.M., & Rothblatt, A. B. (1981). Thermographic measurement of sexual arousal: A discriminant validity analysis. *Archives of Sexual Behavior, 10*, 171–176.

Agocha, V. B., Asencio, M., & Decena, C. U. (2018). Sexuality and culture. In D. L. Tolman, L. M. & Diamond, J. A. (Eds.), *APA handbook of sexuality and psychology* (Vol. 2, pp. 183–228). Washington, DC: American Psychological Association. doi:10.1037/14194-006

Auyeung, B., Baron-Cohen, S., Ashwin, E., Knickmeyer, R., Taylor, K., Hackett, G., Hines, M. (2009). Fetal testosterone predicts sexually differentiated childhood behavior in girls and in boys. *Psychological Science, 20,* 144–148. doi:10.1111/j.1467-9280.2009.02279.x

Bailey, J. M., Vasey, P. L., Diamond, L. M., Breedlove, S. M., Vilain, E., & Epprecht, M. (2016). Sexual orientation, controversy, and science. *Psychological Science in the Public Interest, 17*, 45–101. doi:10.1177/1529100616671516

Bancroft, J., & Janssen, E. (2000). The dual control model of male sexual response: A theoretical approach to centrally mediated erectile dysfunction. *Neuroscience and Biobehavioral Review,* 24, 571–579.

Bancroft, J., Jones, H. G., & Pullan, B. P. (1966). A simple transducer for measuring penile erection with comments on its use in the treatment of sexual disorder. *Behavior Research and Therapy, 4,* 239–241.

Basson, R. (2000). The female sexual response: A different model. *Journal of Sex & Martial Therapy, 26*, 51–65. doi:10.1080/009262300278641

Berman, J., & Bassuk, J. (2002). Physiology and pathophysiology of female sexual function and dysfunction. *World Journal of Urology, 20*, 111–118. doi:10.1007/s00345-002-0281-4

Blanchard, R., Klassen, P., Dickey, R., Kuban, M. E., & Blak, T. (2001). Sensitivity and specificity of the phallometric test for pedophilia in nonadmitting sex offenders. *Psychological Assessment, 13,* 118–126. doi:10.1037//1040-3590.13.1.118

Bohlen, J. G., & Held, J. P. (1979). An anal probe for monitoring vascular and muscular events during sexual response. *Instrumentation, 16,* 318–324.

Bossio, J. A., Singh, M., & Pukall, C. F. (2018). Concurrent assessment of penile blood flow and circumference as indicators of male sexual arousal. *The Journal of Sexual Medicine, 15,* 1570–1578. doi:10.1016/j.jsxm.2018.08.016

Bossio, J. A., Spape, J., Lykins, A. D., & Chivers, M. L. (2014). Observational stance as a predictor of subjective and genital sexual arousal in men and women. *The Journal of Sex Research, 51,* 303–315. doi:10.1080/00224499.2012.729276

Bossio, J. A., Suschinsky, K. D., Puts, D. A., & Chivers, M. L. (2014). Does menstrual cycle phase influence the gender specificity of heterosexual women's genital and subjective sexual arousal? *Archives of Sexual Behavior, 43,* 941–952. doi:10.1007/s10508-013-0233-7

Bouchard, K. N., Chivers, M. L., & Pukall, C. F. (2017). Effects of genital response measurement device and stimulus characteristics on sexual concordance in women. *The Journal of Sex Research, 54,* 1197–1208. doi:10.1080/00224499.2016.1265641

Bouchard, K. N., Dawson, S. J., Shelley, A. J., & Pukall, C. F. (2019). Concurrent measurement of genital lubrication and blood flow during sexual arousal. *Biological Psychology, 145,* 159–166. doi:10.1016/j.biopsycho.2019.05.003

Bouchard, K. N., Timmers, A. D., & Chivers, M. L. (2015). Gender-specificity of genital response and self-reported sexual arousal in women endorsing facets of bisexuality. *Journal of Bisexuality, 15,* 180–203. doi:10.1080/15299716.2015.1022924

Boyer, S. C., Bouchard, K. N., & Pukall, C. F. (2019). Laser Doppler imaging as a measure of female sexual arousal: Further validation and methodological considerations. *Biological Psychology, 148*, 107741. doi:10.1016/j.biopsycho.2019.107741

Boyer, S. C., Pukall, C. F., & Chamberlain, S. M. (2013). Sexual arousal in women with provoked vestibulodynia: The application of laser Doppler imaging to sexual pain. *The Journal of Sexual Medicine, 10*, 1052–1064. doi:10.1111/j.1743-6109.2012.02855.x

Brotto, L. A., Chivers, M. L., Millman, R. D., & Albert, A. (2016). Mindfulness-based sex therapy improves genital-subjective arousal concordance in women with sexual desire/arousal difficulties. *Archives of Sexual Behavior. 45*, 1907–1921. doi:10.1007/s10508-015-0689-8

Carranza-Lira, S., Fragoso-Díaz, N., MacGregor-Gooch, A. L., Garduño-Hernández, M. P., Ríos-Calderón, K., & Aparicio, H. (2003). Vaginal dryness assessment in postmenopausal women using pH test strip. *Maturitas, 45*, 55–58. doi:10.1016/s0378-5122(03)00082-3

Carmichael, M. S., Humbert, R., Dixen, J., Palmisano, G., Greenleaf, W., & Davidson, J. M. (1987). Plasma oxytocin increases in the human sexual response. *The Journal of Clinical Endocrinology, 64*, 27–31.

Carmichael, M. S., Warburton, V. L., Dixen, J., & Davidson, J. M. (1994). Relationships among cardiovascular, muscular, and oxytocin responses during human sexual activity. *Archives of Sexual Behavior*, *23*, 59–79.

Cherner, R. A., & Reissing, E. D. (2013). A psychophysiological investigation of sexual arousal in women with lifelong vaginismus. *The Journal of Sexual Medicine, 10*, 1291–1303. doi:10.1111/jsm.12102

Chivers, M. L. (2005). A brief review and discussion of sex differences in the specificity of

sexual arousal. *Sexual and Relationship Therapy, 20*, 377–390. doi:10.1080/14681990500– 238802

Chivers, M. L. (2017). The specificity of women's sexual response and its relationship with sexual orientations: A review and ten hypotheses. *Archives of Sexual Behavior, 46*, 1161–1179. doi:10.1007/s10508-016-0897-x

Chivers, M. L., & Bailey, J. M. (2005). A sex difference in features that elicit genital response. *Biological Psychology, 70*, 115–120. doi:10.1016/j.biopsycho.2004.12.002

Chivers, M. L., Bouchard, K. N., & Timmers, A. D. (2015). Straight but not narrow; Within-gender variation in the gender-specificity of women's sexual response. *PLoS ONE, 10*(12), e0142575. doi:10.1371/journal.pone.0142575

Chivers, M. L., & Brotto, L. A. (2017). Controversies of women's sexual arousal and desire. *European Psychologist, 22*, 5–26. doi:10.1027/1016-9040/a000274

Chivers, M. L., Rieger, G., Latty, E., & Bailey, J. M. (2004). A sex difference in the specificity of sexual arousal. *Psychological Science, 15*, 736–744. doi:10.1111/j.09567976.2004.00-750.x

Chivers, M. L., Roy, C., Grimbos, T., Cantor, J. M., & Seto, M. C. (2014). Specificity of sexual arousal for sexual activities in men and women with conventional and masochistic sexual interests. *Archives of Sexual Behavior, 43*, 931–940. doi:10.1007/s10508-013-0174-1

Chivers, M. L., Seto, M. C., & Blanchard, R. (2007). Gender and sexual orientation differences in sexual response to sexual activities versus gender of actors in sexual films. *Journal of Personality and Social Psychology, 93*, 1108–1121. doi:10.1037/0022-3514.93.6.1108

Chivers, M. L., Seto, M. C., Lalumière, M. L., Laan, E., & Grimbos, T. (2010). Agreement of self-reported and genital measures of sexual arousal in men and women: A meta-analysis. *Archives of Sexual Behavior, 39*, 5–56. doi:10.1007/s10508-009-9556-9

Chivers, M. L., Suschinsky, K. D., Timmers, A. D., & Bossio, J. A. (2014). Experimental, neuroimaging, and psychophysiological methods in sexuality research. In D. L. Tolman, L. M. Diamond, J. A. Bauermeister, W. H. George, J. G. Pfaus & L. M. Ward (Eds.), *APA handbook of sexuality and psychology* (Vol. 1, pp. 99–119). Washington, DC: American Psychological Association.

Chivers, M. L., & Timmers, A. D. (2012). Effects of gender and relationship context in audio narratives on genital and subjective sexual response in heterosexual women and men. *Archives of Sexual Behavior, 41*, 185–197. doi:10.1007/s10508-012-9937-3

Clifton, J., Seehuus, M., & Rellini, A. H. (2015). Testing cognitive predictors of individual differences in the sexual psychophysiological responses of sexually functional women. *Psychophysiology, 52*, 957–968. doi:10.1111/psyp.12423

Dawson, S. J., Lalumière, M. L., Allen, S. W., Vasey, P. L., & Suschinsky, K. D. (2013). Can habituation of sexual responses be elicited in men and women when attention is maintained? *Canadian Journal of Behavioural Science/Revue canadienne des sciences du comportement, 45*, 274–285. doi:10.1037/a0032848

Dawson, S. J., Sawatsky, M. L., & Lalumière, M. L. (2015). Assessment of introital lubrication. *Archives of Sexual Behavior, 44*, 1527–1535. doi:10.1007/s10508-015-0519-z

Diamond, L. M. (2017). Wanting women: Sex, gender, and the specificity of sexual arousal. *Archives of Sexual Behavior, 46*, 1181–1185. doi:10.1007/s10508-017-0967-8

Dickinson, R. L. (1933). *Human sex anatomy*. Baltimore, MD: Williams and Wilkins.

Fredrickson, B. L., & Roberst, T.-A. (1997). Objectification theory: Toward understanding women's live experiences and mental health risks. *Psychology of Women Quarterly, 21*, 173–206. doi:10.1111/j.1471-6402.1997.tb00108.x.

Freund, K. (1963). A laboratory method for diagnosing predominance of homo- or hetero-erotic

interest in the male. *Behaviour Research and Therapy, 1*, 85–93.

Freund, K., Watson, R., & Rienzo, D. (1989). Heterosexuality, homosexuality, and erotic age preference. *Journal of Sex Research, 26*, 107–117.

Geer, J. H., Lapour, K. J., & Jackson, S. R. T. (1993). The information processing approach to human sexuality. In A. O. N. Birbaumer (Eds.), *The structure of emotion: Psychophysiological, cognitive, and clinical aspects* (pp. 139–155). Kirkland, WA: Hogrefe & Huber Publishers.

Geer, J. H., Morokoff, P., & Greenwood, P. (1974). Sexual arousal in women: The development of a measurement device for vaginal blood volume *Archives of Sexual Behavior, 3*, 559–564.

Gerritsen, J., van der Made, F., Bloemers, J., van Ham, D., Kleiverda, G., Everaerd, W., . . . Tuiten, A. (2009). The clitoral photoplethysmograph: A new way of assessing genital arousal in women. *Journal of Sexual Medicine, 6*, 1678–1687. doi:10.1111/j.1743-6109.2009.01228.x

Graziottin, A., & Gambini, D. (2015). Anatomy and physiology of genital organs – women. *Handbook of Clinical Neurology, 130*, 39–60. doi:10.1016/b978-0-444-63247-0.00004-3

Graziottin, A., & Giraldi, A. (2006). Anatomy and physiology of women's sexual function. In H. Porst & J. Buvat (Eds.), *Standard practice in sexual medicine* (pp. 289–304). Oxford, UK: Blackwell.

Hatch, J. P. (1979). Vaginal photoplethysmography: Methodological considerations. *Archives of Sexual Behavior, 8*, 357–374.

Heiman, J. R. (1977). A psychophysiological exploration of sexual arousal patterns in females and males. *Psychophysiology, 14*, 266–274.

Heiman, J. R., & Rowland, D. L. (1983). Affective and physiological sexual response patterns:

The effects of instructions on sexually functional and dysfunctional men. *Journal of Psychosomatic Research, 27*, 105–116. doi:10.1016/0022-3999(83)90086-7

Henson, D. E., & Rubin, H. B. (1978). A comparison of two objective measures of sexual arousal of women. *Behaviour Research and Therapy*, *16*, 143–151.

Henson, C., Rubin, H. B., & Henson, D. E. (1979). Women's sexual arousal concurrently assessed by three genital measures. *Archives of Sexual Behavior, 8*, 459–469.

Hoon, P. W., Wincze, J. P., & Hoon, E. F. (1976). Physiological assessment of sexual arousal in women. *Psychophysiology*, *13*, 196–204.

Huberman, J. S., & Chivers, M. L. (2015). Examining gender-specificity of sexual response with concurrent thermography and plethysmography. *Psychophysiology, 52*, 1382–1395. doi:10.1111/psyp.12466

Huberman, J. S., Dawson, S. J., & Chivers, M. L. (2017). Examining the time course of genital and subjective sexual responses in women and men with concurrent plethysmography and thermography. *Biological Psychology, 129*, 359–369. doi:10.1016/j.biopsycho.2017.09.006

Huberman, J. S., McInnis, M. K., Bouchard, K. N., Dawson, S. J., Pukall, C. F., & Chivers, M. L. (2019). Exploring comfort levels and the role of compensation in sexual psychophysiology study participation. *Archives of Sexual Behavior, 48*, 2389–2402. doi:10.1007/s10508-019-1458-x

Huberman, J. S., Suschinsky, K. D., Lalumière, M. L., & Chivers, M. L. (2013). Relationship between impression management and three measures of women's self-reported sexual arousal. *Canadian Journal of Behavioural Science*, *45*, 259–273. doi:10.1037/a0033397

Janssen, E. (2002). Psychophysiological measurement of sexual arousal. In M. W. Wiederman & B. E. Whitley (Eds.), *Handbook for conducting research on human sexuality* (pp. 139–

171). Mahwah, NJ: Erlbaum.

Janssen, E., Everaerd, W., Spiering, M., & Janssen, J. (2000). Automatic processes and the appraisal of sexual stimuli: Toward an information processing model of sexual arousal. *Journal of Sex Research, 37*, 8–23. doi:10.1080/00224490009552016

Janssen, E., & Prause, N. (2016). Sexual response. In J. T. Cacioppo, L. G. Tassinary & G. G. Berntson (Eds.), *Handbook of psychophysiology* (4th ed., pp. 284–299). New York, NY: Cambridge University Press.

Kaplan, H. S. (1977). Hypoactive sexual desire. *Journal of Sex and Marital Therapy 3*, 3–9.

Kinsey, A. C., Pomeroy, W. B., & Martin, C. E. (1948). *Sexual behavior in the human male*. Philadephia, PA: W. B. Saunders Company.

Kinsey, A. C., Pomeroy, W. B., Martin, C. E., & Gebhard, P. H. (1953). *Sexual behavior in the human female*. Philadephia, PA: W. B. Saunders Company.

Kuban, M., Barbaree, H. E., & Blanchard, R. (1999). A comparison of volume and circumference phallometry: Response magnitude and method agreement. *Archives of Sexual Behavior, 28*, 345–359.

Kukkonen, T. M., Binik, Y. M., Amsel, R., & Carrier, S. (2010). An evaluation of the validity of thermography as a physiological measure of sexual arousal in a non-university adult sample. *Archives of Sexual Behavior, 39*, 861–873. doi:10.1007/s10508-009-9496-4

Kukkonen, T. M. (2014). What is the best method of measuring the physiology of female sexual arousal? *Current Sexual Health Reports, 6*, 30–37. doi:10.1007/s11930-013-0010-6

Kukkonen, T. M. (2015). Devices and methods to measure female sexual arousal. *Sexual Medicine Reviews, 3*, 225–244. doi:10.1002/smrj.58

Laan, E. (1994). *Determinants of sexual arousal in women.* (Doctoral Degree), University of Amsterdam, Amersterdam, The Netherlands.

Laan, E., & Everaerd, W. (1995). Determinants of female sexual arousal: Psychophysiological theory and data. *Annual Review of Sex Research, 6*, 32–76. doi:10.1080/10532528.1995.10559901

Laan, E., Everaerd, W., & Evers, A. (1995). Assessment of female sexual arousal: Response specificity and construct validity. *Psychophysiology, 32*, 476–485.

Laan, E., Everaerd, W., Van Aanhold, M.-T. & Rebel, M. (1993). Performance demand and sexual arousal in women. *Behaviour Research and Therapy, 31*, 25–35.

Laan, E., Everaerd, W., Van der Velde, J., & Geer, J. H. (1995). Determinants of subjective experience of sexual arousal in women: Feedback from genital arousal and erotic stimulus content. *Psychophysiology, 32*, 444–451.

Laan, E., & Janssen, E. (2007). How do men and women feel? Determinants of subjective experience of sexual arousal. In E. Janssen (Ed.), *The psychophysiology of sex* (pp. 278–290). Bloomington, IN: Indiana University Press.

Laan, E., Sonderman, M., & Janssen, E. (1996, September). *Straight and lesbian women's sexual responses to straight and lesbian erotica: No sexual orientation effects*. Poster presented at the meeting of the International Academy of Sex Research, Provincetown, Massachusetts.

Lalumière, M. L. (2017). On the concept of category-specificity. *Archives of Sexual Behavior, 46*, 1187–1190. doi:10.1007/s10508-017-0965-x

Lalumière, M. L., Babchishin, K. M., & Ebsworth, M. (2018). The use of film clips in a viewing time task of sexual interests. *Archives of Sexual Behavior, 47,* 627–635. doi:10.1007/s10508-017-1108-0

Lalumière, M. L., Quinsey, V. L., Harris, G. T., Rice, M. E., & Trautrimas, C. (2003). Are rapists differentialy aroused by coercive sex in phallometric assessments? *Annals New*

York Academy of Sciences, 989, 211–224. doi:10.1111/j.1749-6632.2003.tb07307.x

Lalumière, M. L., Sawatsky, M. L., Dawson, S. J., & Suschinsky, K. D. (2020). The empirical status of preparation hypothesis: Explicating women's genital responses to sexual stimuli in the laboratory. *Archives of Sexual Behavior.* Advanced online publication. doi:10.1007/s10508-019-01599-5

Lawrence, A. A., Latty, E. M., Chivers, M. L., & Bailey, J. M. (2005). Measurement of sexual arousal in postoperative male-to-female transsexuals using vaginal photoplethysmography. *Archives of Sexual Behavior, 34,* 135-145. doi:10.1007/s10508-005-1792-z-

Levin, R. J. (1992). The mechanisms of human female sexual arousal. *Annual Review of Sex Research, 3,* 1–48. doi:10.1080/10532528.1992.10559874

Levin, R. J. (2003). The ins and outs of vaginal lubrication. *Sexual and Relationship Therapy, 18*, 509–513. doi:10.1080/14681990310001609859

Levin, R. J. (2004). Measuring female genital functions—A research essential but still a clinical luxury? *Sexual and Relationship Therapy, 19*, 191–200. doi:10.1080/1468199041000169-1406

Levin, R., & Riley, A. (2007). The physiology of human sexual function. *Psychiatry, 6*, 90–94. doi:10.1016/j.mppsy.2007.01.004

Lippa, R. A. (2008). Sex differences and sexual orientation differences in personality: Findings from the BBC Internet survey. *Archives of Sexual Behavior, 37*, 173–187. doi:10.1007/s10508-007-9267-z

Luoto, S., & Rantala, M. J. (2017). Specificity of women's sexual response: Proximate mechanisms and ultimate causes. *Archives of Sexual Behavior, 46*, 1195–1198. doi:10.1007/s10508-017-0961-1

Lykins, A. D., Cantor, J. M., Kuban, M. E., Blak, T., Dickey, R., Klassen, P. E., & Blanchard, R. (2010). Sexual arousal to female children in gynephilic men. *Sexual Abuse: A Journal of Research and Treatment, 22,* 279–289. doi:10.1177/1079063210372141

Maner, J. K., Gailliot, M. T., Rouby, D. A., & Miller, S. L. (2007). Can't take my eyes off you: Attentional adhesion to mates and rivals. *Journal of Personality and Social Psychology, 93,* 389–401. doi:10.1037/0022- 3514.93.3.389.

Masters, W. H. (1959). The sexual response cycle of the human female: Vaginal lubrication. *Annals New York Academy of Sciences, 83,* 301–317.

Masters, W. H., & Johnson, V. E. (1966). The vagina. In *The human sexual response* (pp. 68–100). Bronx, NY: Ishi Press International.

McCallum, E. B., & Peterson, Z. D. (2012). Investigating the impact of inquiry mode on self-reported sexual behavior: Theoretical considerations and review of the literature. *Journal of Sex Research, 49,* 212–226. doi:10.1080/00224499.2012.658923

Mechelmans, D. J., Sachtler, W. L., von Wiegand, T. E., Goodrich, D., Heiman, J. R., & Janssen, E. (2017, July). *Finding CPD: The successful measurement of clitoral pulse amplitude using a new clitoral plethysmograph*. Poster presented at the International Academy of Sex Research Meeting, Charleston, SC.

Meston, C. M., Rellini, A. H., & McCall, K. (2010). The sensitivity of continuous laboratory measures of physiological and subjective sexual arousal for diagnosing women with sexual arousal disorder. *The Journal of Sexual Medicine, 7,* 938–950. doi:10.1111/j.1743-6109.2009.01548.x

Meyer-Bahlburg, H. F., Dolezal, C., Baker, S. W., & New, M. I. (2008). Sexual orientation in women with classical or non- classical congenital adrenal hyperplasia as a function of degree of prenatal androgen excess. *Archives of Sexual Behavior, 37,* 85–99.

doi:10.1007/s10508-007-9265-1

Money, J., & Ehrhardt, A. A. (1972). *Man and woman, boy and girl: Differentiation and dimorphism of gender identity from conception to maturity*. Baltimore, MD: Johns Hopkins University Press.

Osborn, C. A., & Pollack, R. H. (1977). The effects of two types of erotic literature on physiological and verbal measures of female sexual arousal. *Journal Sex Research, 13*, 250–256.

Palti, Y., & Bercovici, B. (1967). Photoplethysmographic study of the vaginal blood pulse. *American Journal of Obstetrics & Gynaecology, 97*, 143–153.

Perl, J. I., Milles, G., & Shimozato, Y. (1959). Vaginal fluid subsequent to panhysterectomy. *American Journal of Obstetrics & Gynaecology, 78*, 285–289.

Peterson, Z. D., Janssen, E., & Laan, E. (2010). Women's sexual responses to heterosexual and lesbian erotica: The role of stimulus intensity, affective reaction, and sexual history. *Archives of Sexual Behavior, 39*, 880–897. doi:10.1007/s10508-009-9546-y

Prause, N., Cerny, J., & Janssen, E. (2005). The labial photoplethysmograph: A new instrument for assessing genital hemodynamic changes in women. *Journal of Sexual Medicine, 2*, 58–65. 10.1111/j.1743-6109.2005.20106.x

Prause, N., & Heiman, J. R. (2009). Assessing female sexual arousal with the labial thermistor: Response specificity and construct validity. *International Journal of Psychophysiology, 72*, 115–122. doi:10.1016/j.ijpsycho.2008.11.002

Prause, N., & Janssen, E. (2005). Blood flow: Vaginal photoplethysmography. In I. Goldstein, C. M. Meston, S. Davis, & A. Traish (Eds.), *Textbook of female sexual dysfunction* (pp. 361–369). London, UK: Taylor & Francis Medical Books.

Preti, G., Huggins, G. R., & Silverberg, G. D. (1979). Alterations in the organic compounds of

vaginal secretions caused by sexual arousal. *Fertility and Sterility, 32*, 47–54.

Pulverman, C. S., Hixon, J. G., & Meston, C. M. (2015). Uncovering category specificity of genital sexual arousal in women: The critical role of analytic technique. *Psychophysiology, 10*, 1396–1408. doi:10.1111/psyp.12467

Quinsey, V. L., Steinman, C. M., Bergersen, S. G., & Holmes, T. F. (1975). Penile circumference, skin conductance, and ranking responses of child molesters and "normals" to sexual and nonsexual visual stimuli. *Behavior Therapy, 6*, 213–219. doi:10.1016/S0005-7894(75)80143-2

Rellini, A. H., McCall, K. M., Randall, P. K., & Meston, C. M. (2005). The relationship between women's subjective and physiological sexual arousal. *Psychophysiology, 42*(1), 116–124. doi:10.1111/j.1469-8986.2005.00259.x

Rieger, G., Cash, B. M., Merrill, S. M., Jones-Rounds, J., Dharmavaram, S. M., & Savin-Williams, R. C. (2015). Sexual arousal: The correspondence of eyes and genitals. *Biological Psychology, 104*, 56–64. doi:10.1016/j.biopsycho.2014.11.009

Rieger, G., Chivers, M. L., & Bailey, J. M. (2005). Sexual arousal patterns of bisexual men. *Psychological Science, 16*, 579–584.

Rieger, G., Savin-Williams, R. C., Chivers, M. L., & Bailey, J. M. (2016). Sexual arousal and masculinity-femininity of women. *Journal of Personality and Social Psychology, 111*, 265–283. doi:10.1037/pspp0000077

Riley, A. (2004). The physiology of sexual function. *Psychiatry, 3*, 3–7. doi:10.1383/psyt.3.2.3.30306

Riley, A. J., & Riley, E. J. (1983). Cholinergic and adrenergic control of human sexual responses. In D. Whetley (Ed.), Psychopharmacology and sexual disorders (3rd ed., pp. 125–137). Oxford: Oxford University Press.

Rosenthal, A. M., Sylva, D., Safron, A., & Bailey, J. A. (2012). The male bisexuality debate revisited: Some bisexual men have bisexual arousal patterns. *Archives of Sexual Behavior, 41*, 135–147. doi:10.1007/s10508-011-9881-7

Sakheim, D. K., Barlow, D. H., Beck, J. G., & Abrahamson, D. J. (1985). A comparison of male heterosexual and male homosexual patterns of sexual arousal. *The Journal of Sex Research, 21*, 183–198. doi:10.1080/00224498509551257

Schroder, M., & Carroll, R.A. (1999). New women: Sexological outcomes of male-to-female gender reassignment surgery. *Journal of Sex Education and Therapy, 24*, 137–146.

Sintchak, G., & Geer, J. H. (1975). A vaginal plethysmography system. *Psychophysiology, 12*, 113–115.

Sokolov, E. N. (1960). Neuronal models and the orienting reflex. In M. A. B. Brazier (Ed), *The central nervous system and behavior* (pp. 187–276). Madison, NJ: Josiah Macy Jr Foundation Publications.

Spape, J., Timmers, A. D., Yoon, S., Ponseti, J., & Chivers, M. L. (2014). Gender-specific genital and subjective sexual arousal to prepotent sexual features in heterosexual women and men. *Biological Psychology, 102*, 1–9. doi:10.1016/j.biopsycho.2014.07.008

Styles, S. J., MacLean, A. B., Reid, W. M. N., & Sultana, S. R. (2006). Laser Doppler perfusion imaging: A method for measuring female sexual response. *BJOG: An International Journal of Obstetrics & Gynaecology, 113*, 599–601. doi:10.1111/j.1471-0528.2006.00894.x

Suschinsky, K. D. (2012). *An exploration of genital arousal category-specificity and sexual concordance in men and women.* (Doctor of Philosophy), University of Lethbridge, Lethbridge, Alberta, Canada.

Suschinsky, K. D., Bossio, J. A., & Chivers, M. L. (2014). Women's genital sexual arousal to

oral versus penetrative heterosexual sex varies with menstrual cycle phase at first exposure. *Hormones and Behavior, 65*, 319–327. doi:10.1016/j.yhbeh.2014.01.006

Suschinsky, K. D., Dawson, S. J., & Chivers, M. L. (2017). Assessing the relationship between sexual concordance, sexual attractions, and sexual identity in women. *Archives of Sexual Behavior, 46*, 179–192. doi:10.1007/s10508-016-0874-4

Suschinsky, K. D., Dawson, S. J., & Chivers, M. L. (2020). Assessing gender-specificity of clitoral responses. *The Canadian Journal of Human Sexuality*. Advanced online publication. doi:10.3138/cjhs.2019-0061

Suschinsky, K. D., Huberman, J. S., Maunder, L., Brotto, L. A., Hollenstein, T., & Chivers, M. L. (2019). The relationship between sexual functioning and sexual concordance in women. *Journal of Sex & Marital Therapy, 45*, 230–246. doi:10.1080/0092623x.2018.1518881

Suschinsky, K. D., & Lalumière, M. L. (2011a). Prepared for anything? An investigation of female genital arousal in response to rape cues. *Psychological Science*, *22*, 159–165. doi:10.1177/0956797610394660

Suschinsky, K. D., & Lalumière, M. L. (2011b). Category-specificity and sexual concordance: The stability of sex differences in sexual arousal patterns. *The Canadian Journal of Human Sexuality, 20*, 93–108.

Suschinsky, K. D., Lalumière, M. L., & Chivers, M. L. (2009). Sex differences in patterns of genital sexual arousal: Measurement artifacts or true phenomena? *Archives of Sexual Behavior*, *38*, 559–573. doi:10.1007/s10508-008-9339-8

Suschinsky, K. D., Shelley, A. J., Gerritsen, J., Tuiten, A., & Chivers, M. L. (2015). The clitoral photoplethysmograph: A pilot study examining discriminant and convergent validity. *The Journal of Sexual Medicine, 12*, 2324–2338. doi:10.1111/jsm.13047

Sylva, D., Safron, A., Rosenthal, A. M., Reber, P. J., Parrish, T. B., & Bailey, J. M. (2013). Neural correlates of sexual arousal in heterosexual and homosexual women and men. *Hormones and Behavior, 64,* 673–684. doi:10.1016/j.yhbeh.2013.08.003.

Tavares, I. M., Vardasca, R., Cera, N., Pereira, R., Nimbi, F. M., Lisy, D., . . . Nobre, P. J. (2018). A review of infrared thermography as applied to human sexual psychophysiology. *International Journal of Psychophysiology, 133,* 28–40. doi:10.1016/j.ijpsycho.2018.09.001

Timmers, A. D., Bouchard, K. N., & Chivers, M. L. (2015). Effects of gender and sexual activity cues on the sexual responses of women with multidimensionally defined bisexuality. *Journal of Bisexuality, 15,* 154–179. doi:10.1080/15299716.2015.1023389

van Anders, S. M. (2015). Beyond sexual orientation: Integrating gender/sex and diverse sexualities via sexual configurations theory. *Archives of Sexual Behavior, 44,* 1177–1213. doi:10.1007/s10508-015-0490-8

Van de Velde, T. H. (1926). *Ideal marriage, its physiology and technique*. New York, NY: Random House.

Wagner, G., & Levin, R. J. (1977). Human vaginal fluid, pH, urea, potassium and potential difference during sexual excitement. In R. Gemme & C. C. Wheeler (Eds.), *Progress in sexology: Selected proceedings of the 1976 International Congress of Sexology* (pp. 335–344). New York, NY: Plenum Press.

Wagner, G., & Levin, R. J. (1978). Vaginal fluid. In E. F. E. Hafez & T. N. Evans (Eds.), *The human vagina* (pp. 121–137). Amsterdam, The Netherlands: Elsevier/North Holland.

Waxman, S. E., & Pukall, C. F. (2009). Laser Doppler imaging of genital blood flow: A direct measure of female sexual arousal. *The Journal of Sexual Medicine, 6,* 2278–2285. doi:10.1111/j.1743-6109.2009.01326.x

Webster, J., & Hammer, D. (1983). Thermistor measurement of male sexual arousal. *Psychophysiology, 20*, 111–115. doi:10.1111/j.1469-8986.1983.tb00911.x

Wincze, J. P., Hoon, P., & Hoon, E. F. (1977). Sexual arousal in women: A comparison of cognitive and physiological responses by continuous measurement. *Archives of Sexual Behavior*, *6*, 121–133.

Woodard, T. L., & Diamond, M. P. (2009). Physiologic measures of sexual function in women: A review. *Fertility and Sterility, 92*, 19–34. doi:10.1016/j.fertnstert.2008.04.041

Zuckerman, M. (1971). Physiological measures of sexual arousal in the human. *Psychological Bulletin*, *75*, 297–329.

CHAPTER 2

Genital Lubrication: A Cue-Specific Sexual Response?

Abstract

Women's genital responses are sensitive to the presence and intensity of sexual cues, yet some stimulus features (e.g., male vs. female actors, consensual vs. non-consensual interactions) have little influence on the magnitude of response—a phenomenon called *low cue-specificity*. Genital responses are typically assessed using vaginal photoplethysmography, a measure of vaginal vasocongestion, itself a precursor to lubrication. One explanation for low cue-specificity is the *preparation hypothesis*: Women genitally respond to almost all sexual cues because lubrication functions to protect genital organs from potential injury should vaginal penetration occur. In order to test the preparation hypothesis, both vaginal vasocongestion and introital lubrication were assessed in a sample of 20 women in response to sexually explicit films. While patterns of vasocongestion were consistent with low cue-specificity for gender cues and type of sexual activity, lubrication was specific to women's most preferred sexual stimulus categories. These results are inconsistent with the preparation hypothesis.

The physiological assessment of genital responses in the laboratory has relied, for the most part, on methods that measure changes in genital vasocongestion (Janssen, Prause, & Geer, 2007; Prause & Janssen, 2005). Studies using these measures have revealed substantial gender differences in three related phenomena: *category-specificity* (the degree of correspondence between patterns of genital responses and self-reported sexual orientation; Chivers, 2017), *sexual concordance* (the degree of agreement between genital responses and self-reported sexual arousal to particular stimuli; Chivers, Seto, Lalumière, Laan, & Grimbos, 2010), and *cue-specificity* (the degree of differentiation in sexual responses to various sexual cues; Lalumière, 2017).

Women's genital responses have low cue-specificity (e.g., Chivers & Bailey, 2005; Chivers, Rieger, Latty, & Bailey, 2004; Chivers, Seto, & Blanchard, 2007; Peterson, Janssen, & Laan, 2010; Suschinsky, Lalumière, & Chivers, 2009), especially relative to men, whose genital responses consistently demonstrate high cue-specificity for gender, age, and sexual activity (e.g., Blanchard, Klassen, Dickey, Kuban, & Blak, 2001; Freund, Watson, & Rienzo, 1989; Lykins et al., 2010; Rosenthal, Sylva, Safron, & Bailey, 2012; Sakheim, Barlow, Beck, & Abrahamson, 1985). One explanation for low cue-specificity in women is the *preparation hypothesis* (Suschinsky & Lalumière, 2011), which proposes that women's indiscriminate and seemingly automatic genital responses to any sexual cue functions to prepare the relevant organs for impending sexual activities, thereby preventing injury (also see Chivers, 2005; Laan, 1994; Laan & Everaerd, 1995; Laan & Janssen, 2007; Suschinsky et al., 2009). The preparation hypothesis specifically refers to the protective function of genital lubrication, yet most studies have employed measures of vaginal vasocongestion. This hypothesis, therefore, rests on the assumption that vaginal lubrication is strongly related to vaginal vasocongestion (see Levin, 2003) and should, like vaginal vasocongestion, demonstrate low cue-specificity. The present

study is the first to test the preparation hypothesis by examining cue-specificity using a measure of genital lubrication.

Low Cue-Specificity

The most widely used measure of women's genital response, the vaginal photoplethysmograph (VPP), records changes in vaginal pulse amplitude (VPA) as an index of vaginal vasocongestion. The VPP is considered a valid measure of sexual response in women (Laan, Everaerd, & Evers, 1995; Suschinsky et al., 2009). Using VPP, it has been observed that women produce genital responses to almost any sexual cue and, for androphilic women in particular (i.e., those who report a sexual attraction to men), response magnitude is very similar for sexual stimuli depicting men or women (reviewed by Chivers, 2017). Low cue-specificity for gender cues (i.e., low gender-specificity) has been observed with various stimulus modalities, including audiovisual (e.g., Chivers et al., 2007) and audio-only narratives (e.g., Chivers & Timmers, 2012). It has also been observed with thermography, a measure of genital temperature change as an index of vasocongestion (Huberman & Chivers, 2015). In addition, low gender-specificity has been observed using non-genital measures of sexual arousal or interest, such as measures that assess degree of association of sexual cues (e.g., Snowden & Gray, 2013), eye tracking (e.g., Dawson & Chivers, 2016), viewing time (e.g., Ebsworth & Lalumière, 2012), and pupil dilation (e.g., Rieger et al., 2015).

There is some evidence of sexual orientation differences in gender-specificity. Chivers et al. (2007) found that women who reported exclusive or predominant same-sex sexual attractions produced higher genital responses to low-intensity female sexual stimuli (nude exercise, solo masturbation) compared to male sexual stimuli; gender-specificity was not observed, however, for the higher intensity stimuli (sexual intercourse). Also, Chivers, Bouchard, and Timmers (2015) found that women reporting any degree of gynephilia (i.e., sexual attraction to women)

exhibited higher genital responses to female compared to male sexual stimuli. In these studies, the genital responses of gynephilic women demonstrate higher cue-specificity and category-specificity than those of androphilic women; however, the degree of response differentiation to preferred and non-preferred sexual stimuli did not appear as marked for gynephilic women as it was for gynephilic and androphilic men (Chivers et al., 2007), suggesting that lower gender-specificity is not unique to androphilic women.

One stimulus feature reported to produce relatively greater cue-specificity is the type of sexual activities (Chivers et al., 2007; Suschinsky et al., 2009). For instance, Chivers et al. (2007) found that VPA increased with the intensity of the sexual activities depicted in films, such that intercourse elicited greater increases in VPA than solitary masturbation, and nude exercise elicited the weakest responses. Narratives describing masochism and conventional sex elicit comparable genital responses among androphilic women reporting sexual interest in masochism, but higher genital responses to conventional sex stimuli among women with no sexual interest in masochism (Chivers, Roy, Grimbos, Cantor, & Seto, 2014). The relationship context between men and women featured in sexual narratives has also been found to affect the magnitude of women's genital responses (Chivers & Timmers, 2012). This research suggests that although women's genital responses are relatively less sensitive to gender cues (compared to men's), response differentiation occurs based on other stimulus features.

In light of this research, Spape et al. (2014) presented androphilic women with images of male and female genitals that were stripped of contextual cues (i.e., cues other than the actors' primary and secondary sex characteristics). An advantage of these images over more complex stimuli, such as films, is that gender and sexual activity cues are less confounded with each other. The authors found that depictions of erect penises produced larger genital responses than depictions of flaccid penises, whereas responses to female pubic triangles and aroused vulvas

were comparable. This was the first study to demonstrate gender-specific genital responding among androphilic women. In addition to gender, however, a stimulus intensity effect may have also influenced response patterns insofar as an erect penis is perhaps a more obvious and intense sexual cue than an engorged vulva. These intriguing findings concerning women's genital response patterns and their often-observed low correspondence with stated sexual attractions and self-reported sexual arousal, particularly among androphilic women, have led researchers to hypothesize about the function of women's relatively low genital cue-specificity.

The Preparation Hypothesis

The *preparation hypothesis* offers a functional explanation for women's low genital cue-specificity (Suschinsky & Lalumière (2011a, 2011b). Based on the premise that increased vaginal vasocongestion contributes to the formation of genital lubrication (Levin, 2003), Suschinsky and Lalumière (2011a, 2011b) proposed that genital lubrication is produced automatically in the presence of all sexual activity cues because of the high cost of not becoming lubricated should vaginal penetration occur (i.e., injury to the reproductive tract). Even in the absence of feelings of sexual arousal—such as during nonconsensual sex—it would be beneficial for women to produce sufficient lubrication to prevent injury to their genital organs. According to this hypothesis, therefore, the relatively indiscriminate nature of women's genital response serves a protective function (Chivers, 2005; Laan, 1994; Lann & Janssen, 2007; Suschinsky et al., 2009).

To test this hypothesis, Suschinsky and Lalumière (2011a, 2011b) presented a series of audio-narratives in which cues of consent, violence, and sexual activity (between a man and a woman) varied across narratives. Women's VPA increased to a similar magnitude for all sexual narratives, even though consensual, non-violent sex was the only narrative category to produce a substantial elevation in self-reported sexual arousal. For men, both genital and self-reported

sexual responses were specific to narratives depicting consensual, nonviolent sex. Other studies that have included sexual threat conditions have also found increases in VPA despite an absence of self-reported sexual arousal (Laan et al., 1995; Suschinsky et al., 2009). Also, the women in the Chivers et al. (2014) study who did not report an interest in masochism nonetheless produced greater genital responses to masochistic stimuli compared to neutral, non-sexual stimuli. These findings lend support to the preparation hypothesis; however, the preparation hypothesis posits a protective function of lubrication specifically, and so a more direct test of the hypothesis is to measure lubrication itself.

Quantifying Lubrication as a Sexual Response

Vaginal lubrication is a relatively understudied component of women's sexual response. The formation of vaginal lubrication is preceded by enhanced congestion within the tissues of the vaginal wall due to increased blood flow and concurrent venous constriction (Levin, 2003). The increased capillary pressure forces interstitial fluid to move through the vaginal epithelium, onto the surface of the vaginal canal. These tiny droplets of fluid eventually coalesce to form vaginal lubrication (Janssen, Prause, & Geer, 2007; Levin, 2003, 2004; Masters & Johnson, 1966), which is visible within 10 to 30 seconds of sexual stimulation (Masters, 1959). Once sexual arousal dissipates, vasocongestion resolves and lubrication is reabsorbed by the vaginal epithelium (Levin, 2003; Odeblad, 1964). The relationship between vaginal vasocongestion and lubrication is mostly based on observational research by Masters and Johnson (1966) and has rarely been measured quantitatively. One factor affecting the paucity of research is that there are no well-established methods to quantify vaginal lubrication (Levin, 2003), and until recently (Dawson, Sawatsky, & Lalumière, 2015), there was no measure that could be used repeatedly within a single experimental session (the type of session needed to assess cue-specificity).

Dawson et al. (2015) designed and tested a new device that utilizes a litmus test strip

(LTS) to assess lubrication. Following each stimulus presentation, women were instructed to place the tip of the LTS—consisting of a strip of litmus paper attached to a plastic applicator—at the vaginal introitus for 60 s. During this time, vaginal fluid was absorbed up the length of the litmus paper, producing a color change, which was recorded (in mm) as an index of genital lubrication.

Dawson et al. (2015) assessed the genital responses of androphilic women with both LTS and VPP, and found that lubrication and VPA were higher for sexual films compared to nonsexual films (d = 0.53 and 0.85, respectively). The correlation between lubrication and vaginal vasocongestion was very low, which was unexpected given that increased capillary pressure during sexual arousal (i.e., vasocongestion) is thought to result in the formation of lubrication (Levin, 2003). Self-reported sexual arousal was moderately correlated with lubrication, but not with VPA. These results suggest that lubrication can be elicited in the presence of sexual cues in the laboratory and that the LTS can be used to quantify this sexual response.

Present Study

The primary objective of this study was to use the LTS to assess the cue-specificity of genital lubrication as a direct test of the preparation hypothesis. In addition, we sought to test the sensitivity of the LTS to changes in sexual activity intensity (i.e., partnered versus solitary sexual activity). Based on the preparation hypothesis, we predicted that sexual stimuli of similar intensities would have comparable effects on degree of lubrication, regardless of the gender of individuals depicted in the stimuli.

Method

Participants

The final sample consisted of 20 cisgender women (*M age* = 21.6 years, *SD* = 2.9, range

18-28), all of whom were attending university or had completed a bachelor's degree. Most of the women (80%) were in romantic relationships and, based on responses to a questionnaire item adapted from the Kinsey scale (Kinsey, Pomeroy, & Martin, 1948), 17 were androphilic (i.e., exclusively or mostly sexually attracted to men) and 3 were androgynephilic (i.e., sexually attracted to both men and women). Women were considered androphilic if they provided ratings of 0 or 1 for the Kinsey item, and androgynephilic (n = 3) if they provided ratings of 2, 3, or 4. In terms of self-identified sexual orientation, 16 of the androphilic women self-identified as heterosexual and 1 identified as bisexual. All three androgynephilic women self-identified as bisexual.

At the time of testing, 16 women (80%) were taking some form of hormonal contraceptive. Of the four naturally-cycling women, one was in the follicular phase and three were in the luteal phase of the menstrual cycle. Menstrual cycle phase was estimated using the reverse cycle day method outlined in Lamprecht and Grummer-Strawn (1996). Of the women who experienced sexual activity in the past four weeks, scores on the Female Sexual Function Index (FSFI, Rosen et al., 2000) were all above the clinical cut-off (M = 31.6; range = 27.3 to 34.4; Wiegel, Meston, & Rosen, 2005), suggesting that none were experiencing clinically significant sexual difficulties.

Prospective participants were recruited via advertisements requesting participants for a "sexual arousal study" posted at a Canadian university. Of the 60 women who responded to the advertisements (by telephone or email) and received information about the study, 31 remained interested and underwent eligibility screening to ensure comfort with the experimental procedure and to maximize the likelihood of a sexual response. Eligible participants were between the ages of 18 and 30 and had familiarity with erotica. Women were ineligible if they: had a sexually transmitted infection; were taking medication that could affect their sexual functioning; had a

serious mental illness or substance abuse problem; had a history of sexual dysfunction; were pregnant or trying to conceive; or had never experienced vaginal penetration (e.g., sexual intercourse, digital penetration, tampon use, or pelvic examination). In addition, women were ineligible if they had participated in the Dawson et al. (2015) study. The recruitment advertisement and eligibility screening specified that participants must be using oral hormonal contraceptives. Questionnaire responses indicated that four women were not using oral hormonal contraceptives at the time of testing. Inclusion of their data did not affect the overall pattern of results.

Twenty-one women were eligible to participate and scheduled a laboratory session. Data from one woman were excluded because it was not possible to accurately quantify the amount of lubrication on the LTS due to fluid absorption across the entire litmus paper for all of the LTS trials. Data collection ceased once our target sample size of 20 women with valid data was reached. The target was determined from funding availability and prior research on cue-specificity; the sample size is similar to that of Suschinsky et al. (2009) who examined cue-specificity with VPP, as well as Dawson et al. (2015) who assessed sexual responses with LTS.

Materials

Audiovisual stimuli. The experimental stimuli were comprised of 12, 240 s audiovisual film clips, with two exemplars from six stimulus categories: nonsexual (nature scenes); female solo masturbation (manual self-stimulation); male solo masturbation (manual self-stimulation); female–female partnered sex (oral sex and digital-vaginal penetration); male–male partnered sex (oral sex and penile-anal penetration); and male–female partnered sex (oral sex and penile-vaginal penetration). The sexual films included sexual vocalizations and no music; the nonsexual films were male narrated (also without music). Stimulus categories were chosen to be consistent with Chivers et al. (2007), with the exception that we did not include a nude exercise category.

All experimental stimuli consisted of two, 120 s segments portraying different actors or nature scenes. Each exemplar within a given stimulus category contained segments excerpted from the same two films. For example, one exemplar in a stimulus category consisted of seconds 1 to 120 of Film A followed by seconds 121 to 240 of Film B, while the second exemplar consisted of seconds 1 to 120 of Film B followed by seconds 121 to 240 of Film A. This arrangement was intended to maintain participants' attention throughout each film clip and to control for the possible influence of extraneous features (e.g., characteristics of the actors, environment, or scene) on response patterns across VPA and LTS trials.

Four additional 60 s nonsexual film clips were used as adaptation stimuli (data not used in analyses). Unlike the experimental film clips, the adaptation stimuli contained only one film segment. The adaptation stimuli and the nonsexual experimental stimuli were selected from commercially available nature documentaries and contained only nonsexual content (i.e., no reference to sex or reproduction) about plants and animals (i.e., humans were not depicted in the films). Previous studies in our laboratory (e.g., Dawson et al., 2015) confirmed that these nonsexual films do not elicit physiological or self-reported sexual responses.

The sexual film clips were selected from open-access websites and have not been used in prior research studies. The need for longer film clips to elicit measurable lubrication at the introitus precluded us from using the 60-90 s films used in other studies in our laboratory. In order to determine whether the films elicited the intended responses, they were tested with a sample of gynephilic men whose penile responses were assessed with circumferential PPG (results are available on request). Men were selected to test the stimuli because research has consistently found that their sexual responses are specific to stimuli that correspond to self-stated sexual attractions and preferences, and that responses to preferred sexual stimuli increase with the intensity of the sexual activity depicted (e.g., Chivers et al., 2007). Indeed, penile responses

and self-reported sexual arousal showed the expected variation as a function of actor gender (i.e., responses were greater for female sexual stimuli compared to those depicting only men; responses to male sexual stimuli were comparable to a nonsexual stimulus). Continuously rated self-reported sexual arousal also varied as a function of stimulus intensity, whereas penile responses were no greater for stimuli depicting female partnered versus solitary sex. The latter does not appear to be a result of a ceiling effect because we considered the entire film, as well as the first 90 s. Nonetheless, the films were considered appropriate to test the cue-specificity of women's genital responses, but the analyses for stimulus intensity should be interpreted cautiously.

All stimuli were presented on a 52 cm computer monitor situated at eye-level approximately 150 cm from the participants. The participants wore noise-cancelling headphones to hear the audio component of the films.

Vaginal vasocongestion. Changes in vaginal vasocongestion were assessed with a VPP (Technische Handelsonderneming Coos, Purmerend, The Netherlands), which records VPA continuously throughout each film clip using Limestone Technologies Inc. (Odessa, ON, Canada) DataPac_USB and Preftest software, Version 10. Data were recorded at a rate of 10 samples/s and band-pass filtered (0.5-10 Hz) and the amplitude of each pulse wave was recorded in millivolts (mV).

The VPP involves a small tampon-shaped acrylic probe—containing a light-emitted diode and a light receptor—that is inserted vaginally. As the vaginal tissues engorge with blood they become less transparent, resulting in more light reflected back from the tissues to the probe. VPA is thought to represent the phasic changes in vasocongestion associated with each heartbeat (larger amplitudes reflect greater vasocongestion). A silicone anchor was attached to the cable of the VPP to ensure that the orange-red spectrum light source and photodiode light detector

remained inserted to a correct and consistent depth (i.e., photodiode 5 cm from the silicone anchor) and orientation throughout the session and across participants.

Prior to data analysis, an experimenter (masked to stimulus category) removed movement artifacts by visual inspection. The average number of edited movement artifacts per valid female participant across all experimental trials was 11.1 (median = 4.5). After each testing session, the VPP was subjected to a high-level disinfection protocol (Prause & Janssen, 2005).

Genital lubrication. Genital lubrication was assessed using a litmus test strip (LTS; Dawson et al., 2015). The LTS consists of a strip of blue litmus paper (4.7 cm x 0.6 cm; Precision Laboratories, Cottonwood, AZ) attached to one side of a sterile white plastic applicator (14.7 x 1.7 cm). The litmus paper is attached vertically (i.e., perpendicular to the base of the applicator) to the test side of the applicator with double-sided medical-grade adhesive tape. On the other side of the applicator (the marker side), a strip of bright blue medical-grade adhesive tape (one-sided) is attached horizontally, 1 cm from the base of the applicator. The blue tape acts as a placement marker, indicating the target depth of insertion (1 cm).

Women were instructed to place the LTS applicator at the introitus for 60 s immediately following each film clip presentation. To facilitate the placement of the applicator, women were directed to position a small freestanding mirror in front of their vulva. Using one hand, they parted their labia to prevent it from coming into contact with the litmus paper. With the other hand, they inserted the LTS with the test side facing downward so that the litmus paper was not visible to the participants. A new LTS was used for each trial.

The amount of lubrication was quantified by measuring the length of color change on the litmus paper (in mm). We recorded the distance from the base of the applicator to the highest continuous point of color change on the litmus paper. Immediately following the experimental session, two independent raters (masked to the stimulus category) used digital calipers to

measure the length of the color change to the nearest 0.01 mm. The within-participant inter-rater Pearson *r* correlation for the six experimental trials varied from .76 to 1.00 (overall average across all 20 participants = .92; median = .98). The average of the two raters was used in the analyses reported below.

Self-reported sexual arousal. Throughout each stimulus presentation, women were asked to continuously rate their sexual arousal by pressing the plus ("+") and minus ("-") keys on a keypad. They were instructed to press the plus key whenever they felt an increase in sexual arousal and the minus key whenever they feel a decrease in sexual arousal; this corresponded to the increase and decrease of a green bar on the side of the computer screen, which ranged from 0 (no sexual arousal) to 100 (maximum degree of sexual arousal, similar to that experienced before orgasm).

Women were also asked to rate their sexual arousal ("*How aroused did you feel during the film*?") and their perceived genital response ("*How aroused did your genitals feel during the film*?") after each stimulus presentation using a 9-point Likert scale, where 1 was the lowest level of response (i.e., no arousal) and 9 was the highest level of response (i.e., similar to the arousal experienced before orgasm). The post-stimulus questions were presented successively on the computer screen and women rated their sexual arousal by pressing a number on the keypad.

Questionnaires. Women completed a questionnaire package regarding their biographical information, sexual history, sexual interests, and sexual functioning. Degree of gynephilia and/or androphilia was assessed using a questionnaire item adapted from the Kinsey scale (Kinsey et al., 1948; Kinsey et al., 1953). They rated their sexual attraction on a 7-point scale, where 0 reflected sexual attraction exclusively to individuals of the opposite sex, 3 reflected equal attraction to men and women, and 6 reflected exclusive attractions to individuals of the same sex.

The questionnaire package also contained questions related to hormonal contraceptive

use and menstrual cycle information, and included the FSFI (Rosen et al., 2000). The FSFI is a brief 19-item self-report measure that assesses sexual functioning in the past four weeks across six domains: desire, subjective arousal, lubrication, orgasm, global satisfaction, and pain. Higher scores indicate better sexual functioning. Wiegel et al. (2005) proposed that a total score of 26.55 or less total is indicative of sexual dysfunction. The measure has shown excellent internal consistency across all domains in previous studies (α range= 0.89 to 0.96) and good test-retest reliability (2-4 weeks; ranging from r = .79 to .86; Rosen et al., 2000). Internal consistency ranged from 0.47 to 0.88 in the present sample.

Procedure

The University of Ottawa Research Ethics and Integrity Board reviewed and approved all experimental procedures in accordance with the ethical guidelines of the Canadian Tri-Council Policy Statement.

Screening. Prospective participants contacted the laboratory by phone or by email. The experimenter (either the first author or a research assistant) provided preliminary information about the study and outlined the eligibility criteria. Women who remained interested in participating and who met the eligibility criteria scheduled an appointment for the experimental session when they would not be menstruating. Women were instructed to refrain from sexual activity 24 hours prior to testing and from physical exercise 1 hour prior to testing (Meston & Gorzalka, 1996), and were also asked to refrain from using alcohol, tobacco, cold medications, and recreational drugs on the day of testing. Questionnaire responses confirmed that all participants complied with these instructions.

Session. Women were tested individually by a female experimenter. First, they received a detailed explanation of the experimental procedure and instructions regarding the use of the genital devices. After reading and signing the consent form, they were left alone in the dimly lit

room. Once alone, they were instructed to undress from the waist down and to sit comfortably in a reclining chair situated in front of the computer monitor. For the VPP trials, women were asked to place the genital devices. For the LTS trials, women were asked to lightly wipe their vulva using a tissue in order to remove excess vaginal fluid. They were instructed to inform the experimenter when they were ready to begin the session. Communication was available with a hands-free intercom; the experimenter responded either using text messages that appeared on the participant computer monitor or responded verbally, when required.

The experimental session was composed of three parts. First, genital responses were assessed using one of the two measurement devices—either VPP or LTS—while a series of film clips was presented. (It would be difficult with the current technology to assess VPA and lubrication concurrently, because both measures required insertion in the same area.) Next, women were asked to redress and complete the questionnaire package (approximately 20 min) before continuing the experiment using the other genital device. The order of the session (either VPP or LTS first) was counterbalanced across participants. The genital responses of 10 women were first assessed with VPP, followed by LTS; the order was reversed for the other 10 women.

The VPP and LTS trials followed a similar experimental procedure. First, women were presented with two, 60 s nonsexual adaptation stimuli followed by a series of six sexual and nonsexual experimental stimuli. The purpose of the adaptation trials was to allow women to familiarize themselves with the genital devices and the testing procedure (the procedure for the adaptation and experimental trials was identical). After the adaptation trials, a text message appeared on the computer monitor asking participants whether they had any questions or concerns before continuing with the session (none of the participants indicated that they had question or concerns).

The experimental stimuli for both the VPP and LTS trials consisted of six 240-s film

clips, with one exemplar from each of the six stimulus categories. The order of the stimulus presentations was randomized for each participant. Women were asked to respond as naturally as possible to the films and to avoid any movements (e.g., muscles contractions, genital touching, coughing, or talking). During each film clip, women were asked to continuously rate their self-reported sexual arousal.

The interstimulus interval was 300 s. Immediately following the end of each film clip for the LTS trials, women were instructed to position the freestanding mirror on the chair, so that a reflection of their vulva was visible. Next, they were instructed to place the LTS at the introitus, using their reflection to ensure proper placement. The LTSs were located on a table within arm's reach of the participants and were individually packaged in resealable plastic bags that were labeled and organized according to trial number. Once the LTS was in place, women informed the experimenter by saying "start" out loud. After 60 s, the experimenter posted the word "stop" on the computer monitor, signaling the woman to remove the LTS from the introitus and place it back into the plastic resealable bag (lubrication does not continue to run on the LTS after removal from the introitus). They were directed to place the bag with the used LTS into a drop box, and to sit comfortably in the reclining chair until the presentation of the self-report sexual response questions. For the VPP trials, women were instructed to simply sit comfortably after each film clip presentation.

The two post-stimulus self-reported sexual arousal questions were presented one at a time on the computer monitor, and appeared 120 s following the end of each film clip to ensure that women answered the questions at exactly the same time for the LTS and VPP trials. After making their ratings, women were instructed to sit comfortably until the word "read" appeared on the computer monitor (180 s after the end of each film clip). At this time, women read out loud from a magazine (with no sexual content). This distraction task provided the opportunity for

their genital responses to return to baseline (inspection of the data revealed that VPA responses of two women did not fully return to baseline for three trials). Women were instructed to cease reading when they heard a ringing bell via the headphones, which was sounded 275 s after the end of film clip (i.e., they read for 95 s). Before the next film began, women were asked (via a message on the computer monitor) to move the green bar to a position representative of their current degree of self-reported sexual arousal.

At the end of the entire experiment (i.e., after the trials involving the second genital device) women were debriefed about the purpose of the study and were provided $60 CND compensation. The entire session was approximately 3.5 hours in length.

Data Analysis

Although it is common in VPP studies to subtract the initial value at the onset of the film (baseline) from the mean (e.g., Chivers et al., 2007) or peak (e.g., Suschinsky et al., 2009) response, here we present mean VPA response during the 240 s film clip. Analyzing the mean is more similar to the analyses performed for the LTS data, for which there was no baseline measure. In this study, the within-subject correlation between women's mean and mean-minus-baseline VPA across all stimuli was, $r(18) = .57$, 95% CI [0.33, 0.74]. The overall pattern for the results presented below is comparable using mean and mean-minus-baseline.

The correlation between genital responses and self-reported sexual arousal (i.e., sexual concordance) was calculated using within-subject correlations to allow for comparison with other studies (e.g., meta-analysis by Chivers et al., 2010). The Pearson correlation coefficient (r) was computed for each participant and a Fisher's z transformation was applied. The 95% confidence intervals (CI) were calculated around the mean of the z-transformed coefficient. Next, the coefficient and the 95% CI were transformed back to r.

Effect sizes for the difference between stimulus categories were calculated following the

method outlined by Borenstein, Hedges, Higgins, and Rothstein (2009, pp. 28-30). To calculate Cohen's *d*, a difference score was computed between the means of the two within-subject variables being compared (e.g., mean VPA for male–female partnered sex versus nonsexual stimuli) and was divided by *the standard deviation (SD) within groups*, taking into account the correlation between the pairs of data. The standard deviation within groups is the *SD* of the differences between all pairs of data.

Cohen's *d* tends to overestimate the effect size in small samples (Borenstein et al., 2009); therefore, a correction factor was applied to *d*, resulting in Hedge's *g* (Hedges, 1981). Even for small sample sizes, the difference between Cohen's *d* and its corrected form, Hedge's *g*, is very small. Readers can interpret *g* as they would *d*. All effect sizes are presented with 95% CI, which were calculated based on the standard error of *g* (see Borenstein et al., 2009, pp. 28-30) using critical *t* values. The error bars on the figures are within-subject 95% CIs, calculated based on the method proposed by O'Brien and Cousineau (2014).

Results

Because of sexual orientation differences in women's genital response cue-specificity (e.g., Chivers et al., 2007; Rieger et al., 2015), analyses comparing responses to different stimulus categories were performed with only the 17 androphilic women; the analyses looking at the rank-preferred stimulus categories included all women.

Genital Lubrication

As shown in Figure 2.1, mean lubrication was higher for the male–female partnered sex category compared to the other sexual stimulus categories: female–female sex, $g = 0.41$, 95% CI [-0.03, 0.90], female masturbation, $g = 0.60$ [0.28, 0.98], male–male sex, $g = 0.69$ [0.06, 1.40], and male masturbation, $g = 0.54$ [0.17, 0.97]. Male–female partnered sex was the only category to elicit more lubrication than the nonsexual category; the response to the other sexual stimulus

categories was comparable to the nonsexual category: female–female sex, g = 0.14 [-0.43, 0.71], female masturbation, g = -0.12 [-0.56, 0.31], male–male sex, g = -0.14 [-0.76, 0.47], and male masturbation, g = -0.03 [-0.60, 0.54]. Mean lubrication was also similar when comparing male and female sexual stimuli depicting solitary masturbation, g = 0.10 [-0.32, 0.53], and partnered sex, g = -0.26 [-0.91, 0.35]. The intensity of sexual activity did not appear to affect the responses: female–female partnered sex compared to female masturbation, g = 0.23 [-0.16, 0.65], male–male partnered sex compared to male masturbation, g = -0.12 [-0.75, 0.50].

Vaginal Vasocongestion

As shown in Figure 2.2, androphilic women's mean VPA was comparable across sexual stimulus categories. Unlike lubrication, mean VPA for male–female partnered sex was not substantially higher than female–female sex, g = 0.14, 95% CI [-0.18, 0.47], male–male sex, g = 0.25 [-0.03, 0.57], and male masturbation, g = 0.10 [-0.09, 0.29]. VPA was higher for male–female sex compared to female masturbation, g = 0.31 [0.02, 0.63]. Mean VPA did not differentiate between male and female sexual stimuli depicting masturbation, g = 0.17 [-0.45, 0.17], or partnered sex, g = -0.26 [-0.12, 0.48]. Also unlike lubrication, VPA increased in response to all sexual stimulus categories compared to the nonsexual category: male–female sex, g = 0.66 [0.32, 1.06], female–female sex, g = 0.40 [0.22, 0.63], female masturbation, g = 0.28 [0.08, 0.51], male–male sex, g = 0.59 [0.31, 0.94], and male masturbation, g = 0.94 [0.56, 1.41].

Sexual activity intensity appeared to have a small effect on mean VPA for female–female sex compared to female masturbation, g = 0.18, 95% CI [0.04, 0.33], but not for male–male sex compared to male masturbation, g = -0.15 [-0.57, 0.33]. To account for the possibility that a ceiling effect prevented the detection of a stimulus intensity effect, we examined genital responses during the first 90 s of the stimuli (90 s is the stimulus length used in previous research examining the intensity effect, such as Chivers et al., 2007): VPA for female–female sex was no

higher than female masturbation, g = 0.12 [-.16, 0.41], and VPA for male–male sex was no higher than male masturbation, g = -0.15 [-0.74, 0.42]. Sexual activity intensity therefore had little, if any, effect on VPA and lubrication response magnitude.

In terms of the relationship between VPA and lubrication, the average within-subject correlation between the two genital responses for all women was, $r(18)$ = .28, 95% CI [0.09, 0.45] when calculated across all six stimulus categories and, $r(18)$ = .17 [-0.10, 0.42] across the five sexual stimulus categories.

Self-Reported Sexual Arousal

Across all three methods of assessing self-reported sexual arousal, androphilic women consistently rated the male–female sexual stimulus as more sexually arousing than the other sexual stimuli (as a group; see Figure 2.3). We did not observe an effect of sexual activity intensity: Partnered sex was not rated as more sexually arousing than solitary masturbation for the male-only nor female-only stimuli.

Concordance

Table 2.1 presents within-subject correlations between women's genital and self-reported responses across all six stimulus categories and across the five sexual categories (androphilic and androgynephilic women combined). Due to a technical malfunction, continuous self-reported sexual arousal was not recorded for one of the androphilic women's LTS trials; her data are not included in the continuous sexual arousal concordance scores. Overall, there was concordance between each of the genital responses assessed (lubrication, VPA) and the three methods of assessing self-reported sexual arousal (continuous, post-stimulus sexual arousal, post-stimulus genital response).

To compare our results to those of Dawson et al. (2015) we performed between-subject correlations for the androphilic women to examine the relationships between lubrication, VPA,

and post-stimulus self-reported sexual responses to the male–female sexual stimulus. As shown in Table 2.2, the pattern of results is similar to that of Dawson et al., whereby the associations between genital and self-reported responses were stronger for lubrication than for VPA. Also, the between-subject correlation between lubrication and VPA was very small and the confidence interval included 0.

Rank-Preferred Sexual Stimulus Category

For each of the 20 women, we rank-ordered the sexual stimulus categories based on her continuous self-reported sexual arousal ratings (stimuli were ranked for each participant, separately for VPP and LTS). This allowed us to examine the sexual stimulus preferences of all female participants irrespective of sexual orientation. A woman's 1st rank-preferred sexual stimulus category refers to the category that elicited (for her) the highest mean continuous self-reported sexual arousal; a film ranked as 5th refers to the category for which the woman provided the lowest mean rating. We rank-ordered stimuli based on continuous sexual arousal because there was more variability compared to post-stimulus ratings (i.e., films eliciting the same post-stimulus ratings for a participant could not be rank-ordered).

As shown in Table 2.3, male–female partnered sex was most frequently represented within the 1st rank-preferred category and male–male partnered sex was most frequently in the 5th. In one instance, the mean continuous self-reported sexual arousal rating was the same for two films; the order of the two films was determined using the participant's post-stimulus rating for self-reported sexual arousal. Continuous self-reported sexual arousal was not recorded for one woman's LTS trials; her data are not included in this set of analyses because we could not rank-order her stimulus categories.

Figure 2.4 presents the mean lubrication response as a function of rank-preferred sexual stimulus categories; the average of the mean continuous sexual arousal ratings is presented in

parentheses for each stimulus category. Amount of lubrication was greater for women's most preferred (1st) sexual category compared to the 3rd, *g* = 0.63, 95% CI [0.22, 1.10], the 4th, *g* = 0.51 [0.14, 0.92], and the 5th, *g* = 0.57 [-0.02, 1.20]. Lubrication was comparable for the 1st and 2nd rank-preferred categories, *g* = -0.09 [-0.33, 0.30], and these were the only categories that elicited more lubrication than the nonsexual stimulus. Amount of lubrication for the 3rd, *g* = -0.09 [-0.39, 0.20], 4th, *g* = 0.04 [-0.45, 0.54], and 5th, *g* = -0.04 [-0.67, 0.58], rank-preferred categories was comparable to the nonsexual stimulus.

A different pattern emerged when conducting the same analyses with VPA (see Figure 2.5). VPA was comparable across all sexual stimulus categories. For instance, VPA for the 1st rank-preferred stimulus was no greater than the 2nd, *g* = 0.004, 95% CI [-0.10, 0.11], 3rd, *g* = 0.05 [-0.21, 0.32], 4th, *g* = 0.15 [0.006, 0.32], or 5th, *g* = 0.02 [-0.35, 0.39]. All rank-preferred sexual stimuli elicited greater VPA compared to the nonsexual stimulus: 1st, *g* = 0.46 [0.27, 0.69], 2nd, *g* = 0.44 [0.25, 0.66], the 3rd, *g* = 0.50 [0.22, 0.82], the 4th, *g* = 0.27 [0.12, 0.44], and the 5th, *g* = 0.77 [0.39, 1.21].

Discussion

This was the first study to examine the cue-specificity of genital lubrication for gender and activity cues. Increases in lubrication (relative to the nonsexual stimulus) were only observed when androphilic women were presented with stimuli depicting male–female partnered sex; the amount of lubrication was similar across all other sexual and nonsexual stimuli. Using a novel analytic approach that allowed for the inclusion of all participants regardless of sexual orientation (rank-preferred categories), we found substantial increases in lubrication only for participants' 1st and 2nd most preferred sexual stimulus categories. Thus, lubrication appeared to be specific to a particular stimulus composition—an amalgamation of cues (e.g., gender, sexual activity, relational) that, together, were most appealing to the participant. In contrast to

lubrication, and similar to a large body of research, VPA did not vary according to stimulus preference. Replicating previous research, VPA demonstrated low cue-specificity for gender (e.g., Chivers et al., 2007) and was not related to genital lubrication in most analyses (Dawson et al., 2015).

These findings are inconsistent with the preparation hypothesis, which predicts that genital lubrication should occur in response to any sexual cue, regardless of sexual preference or interest. In this study, the amount of lubrication elicited by sexual stimuli rated as less sexually appealing was comparable to the nonsexual stimulus. Presumably, the wetness on the LTS for these stimuli corresponded to basal vaginal fluid; that is, the fluid present in the unaroused vagina. According to Levin (2003), the amount of basal fluid is insufficient for painless penetration and so a different mechanism is responsible for enhanced lubrication in response to sexual stimulation. In this study, we did not include a trial baseline measure of vaginal wetness because pilot-testing revealed that multiple pre- and post-stimulus LTS measurements resulted in vaginal drying for some women. It is conceivable that vaginal lubrication was produced in response to all stimuli, including the non-sexual film, but to varying degrees. If the amount produced was sufficient to protect the relevant organs, then the preparation hypothesis may not be in jeopardy. We find it unlikely, however, that the non-sexual stimulus would produce a lubrication response when examination of the data showed no pre-post changes in VPA for the non-sexual stimulus. Also, other studies using VPP (e.g., Both & Laan, 2007) or other genital response measures (e.g., thermography: Huberman & Chivers, 2015) do not show pre-post changes to non-sexual stimuli.

While vaginal vasocongestion has been described as a reflexive response, triggered by any sexual stimulus (e.g., Suschinsky & Lalumière, 2011a), it is possible that lubrication only forms following further processing of stimuli. To the extent that lubrication functions to ready

the reproductive organs for sexual activity, substantial increases in lubrication may occur only in response to cues indicating a high possibility of sexual activity, such as the actual experience of sexual activity (consensual or non-consensual) or the presentation of sexual stimuli that elicit strong feelings of sexual arousal (e.g., above a certain threshold; the group data in Figure 4 suggest 40% of self-reported sexual arousal).

This idea is consistent with the information processing model of sexual arousal (e.g., Janssen, Everaerd, Spiering, & Janssen, 2000), which posits that there are two stages of cognitive processing of sexual stimuli that differentially influence sexual responding. The initial processing stage involves automatic appraisal of sexual cues and primes the genital response system for activation, whereas later cognitive processing is responsible for the self-reported experience of arousal. Results from a recent eye-tracking study support the hypothesis that there are several stages of sexual stimulus processing, which differentially affect patterns of sexual response in terms of cue-specificity: Using eye-tracking, Dawson and Chivers (2016) found that women's initial attentional processing demonstrated low cue-specificity for gender while subsequent attentional processing was biased towards preferred sexual targets. Supporting the hypothesis that initial attention may be responsible for early-stage genital responding, Rieger et al. (2015) observed low gender-specificity for pupil dilation (an index of autonomic arousal), which was positively associated with VPA.

Further evidence to support vaginal vasocongestion as early-stage genital responding comes from studies reporting that changes in VPA precede self-reported sexual arousal (Huberman, Dawson, & Chivers, 2017) and other physiological responses, such as clitoral vasocongestion (Gerristen et al., 2009) and labial temperature (Huberman & Chivers, 2015). If these methods assess later-occurring genital responding, this may explain why self-reported sexual arousal is more strongly associated with changes in genital temperature than VPA (r = .55

versus .26, respectively; meta-analysis by Chivers et al., 2010), as is the case for lubrication. Later-stage processing of sexual stimuli might be contingent on the presence of preferred sexual cues, which may influence the cue-specificity of later-stage genital responding (e.g., lubrication) by evoking feelings of sexual arousal and desire. To elucidate whether genital responses become more highly differentiated over time, research is needed on the time course of genital responding to lengthy stimuli that elicit variation in self-reported sexual arousal.

In the present study, concordance between genital and self-reported sexual responses differed based on analyses performed. Within-subject concordance estimates were similar for LTS and VPP when considering sexual stimuli only, but were higher for VPA when considering all stimulus categories. This is not surprising: By including the neutral stimulus, we ensured the only strong source of variation in VPA response was included, thereby inflating concordance estimates; analyses with only sexual stimuli, on the other hand, show stronger correlation for LTS because different sexual stimuli produced different degrees of lubrication. Consistent with the Dawson et al. (2015) between-subject concordance estimates, self-reported sexual arousal was more strongly correlated with lubrication than VPA; however, confidence intervals for all between-subject correlations were wide and crossed zero, suggesting substantial variability. If lubrication indicates a later stage of sexual arousal than VPA, correlations between lubrication and self-reported arousal, especially post-stimulus sexual arousal, should be higher than for VPA—studies with larger samples should investigate this possibility.

The results of this study further support the specificity and reliability of the LTS as a measure of sexual response. Comparison of our data with that of Dawson et al. (2015) revealed similarities in effect size and average mm of lubrication. The strong correlation between lubrication and self-reported sexual arousal provides further evidence of convergent validity for the LTS as a measure of sexual response. Potential limitations of the LTS are discussed in

Dawson et al. For instance, the addition of an anchor would facilitate accurate and consistent placement of the LTS. A limitation specific to the current study is that the amount of lubrication assessed by the LTS at the introitus may not accurately represent the degree of lubrication formed deeper in the vaginal canal and, as such, it is possible that all sexual stimuli produced small (but functional) amounts of lubrication that were undetectable using a litmus strip at the introitus. The development of a measure of genital lubrication that does not rely on introital lubrication would provide an opportunity to further test of preparation hypothesis and to better understand female genital responses. We find it puzzling that 60 years after Masters' (1959) report on lubrication, researchers have still not developed such a measure.

Another limitation of the current study is the sample size. The typical response pattern for VPP was replicated with our sample, as well as the concordance estimates. Having found evidence of cue-specificity for LTS but not for VPP suggests that our sample was large enough to detect differences; however, a larger sample size would produce more convincing results. We encourage replication from independent researchers using a larger sample size.

Somewhat surprisingly, we did not observe an effect of sexual activity intensity on genital or self-reported sexual responses. In order to compare our results with studies reporting an intensity effect (e.g., Chivers et al., 2007; Suschinsky et al., 2009) and to account for the possibility of a ceiling effect, we analysed the first 90 s of the sexual stimuli; again, we found similar responses to partnered and solitary sex. Bouchard, Chivers, and Pukall (2017) also did not find an intensity effect for VPA when participants were presented with an intercourse stimulus and a foreplay stimulus (e.g., kissing, undressing, manual stimulation). It is possible that other sexual cues (e.g., sexual vocalizations, nudity) influence the elaborative processing of the stimuli, and that stimulus differences across studies are responsible for the different results. For instance, the Chivers et al. stimuli included sexual vocalisations (e.g., moaning) for partnered

but not solitary sex stimuli, which may have led to greater elaboration of the sexual cues within the former. The accumulating evidence of the sensitivity of women's genital responses to various contextual cues (see Chivers, 2017) highlights the challenge of comparing results from studies using different audiovisual stimulus sets.

Replication is needed to confirm whether lubrication is a cue-specific response, strongly related to the experience of sexual arousal. It is possible that increases in vaginal vasocongestion result in the formation of lubrication only under certain conditions. If so, this suggests that our understanding of the basic physiological components of women's genital response—and how these interact with cognitive processes—may be incomplete. Speculation about the relationship between VPA and lubrication may be premature given the lack of clarity as to which physiological process the VPP actually measures (see Prause & Janssen, 2005)—whether it is indeed vasocongestion or some other process, such as vasomotion (Levin & Wylie, 2008). Comparing LTS responses to other genital response measures (e.g., thermography, laser Doppler imaging) may elucidate the relationships among the many physiological components of the sexual response (Huberman et al., 2017). While no firm conclusions can be drawn regarding the state of the preparation hypothesis, the results of this study nevertheless call it into question as an explanation for the low cue-specificity observed for vaginal vasocongestion.

References

Blanchard, R., Klassen, P., Dickey, R., Kuban, M. E., & Blak, T. (2001). Sensitivity and specificity of the phallometric test for pedophilia in nonadmitting sex offenders. *Psychological Assessment, 13*, 118-126. doi:10.1037//1040-3590.13.1.118

Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2009). *Introduction to meta-analysis*. West Sussex, UK: John Wiley & Sons, Ltd.

Both, S., & Laan, E. (2007). Simultaneous measurement of pelvic floor muscle activity and vaginal blood flow: A pilot study. *The Journal of Sexual Medicine, 4*, 690-701. doi: 10.1111/j.1743-6109.2007.00457.x

Bouchard, K. N., Chivers, M. L., & Pukall, C. F. (2017). Effects of genital response measurement device and stimulus characteristics on sexual concordance in women. *The Journal of Sex Research*. Advanced online publication. doi:10.1080/00224499.2016. 1265641

Chivers, M. L. (2005). A brief review and discussion of sex differences in the specificity of sexual arousal. *Sexual and Relationship Therapy, 20*, 377–390. doi:10.1080/1468199050 0238802

Chivers, M. L. (2017). The specificity of women's sexual response and its relationship with sexual orientations: A review and ten hypotheses. *Archives of Sexual Behavior*. Advanced online publication. doi:10.1007/s10508-016-0897-x

Chivers, M. L., & Bailey, J. M. (2005). A sex difference in features that elicit genital response. *Biological Psychology, 70*, 115–120. doi:10.1016/ j.biopsycho.2004.12.002

Chivers, M. L., Bouchard, K. N., & Timmers, A. D. (2015). Straight but not narrow; Within-gender variation in the gender-specificity of women's sexual response. *PLoS One, 10*. doi:10.1371/journal.pone.0142575

Chivers, M. L., Roy, C., Grimbos, T., Cantor, J. M., & Seto, M. C. (2014). Specificity of sexual arousal for sexual activities in men and women with conventional and masochistic sexual interests. *Archives of Sexual Behavior, 43*, 931-940. doi:10.1007/s10508-013-0174-1

Chivers, M. L., Seto, M. C., & Blanchard, R. (2007). Gender and sexual orientation differences in sexual response to sexual activities versus gender of actors in sexual films. *Journal of Personality and Social Psychology, 93*, 1108–1121. doi:10.1037/0022-3514.93.6.1108

Chivers, M. L., Seto, M. C., Lalumière, M. L., Laan, E., & Grimbos, T. (2010). Agreement of self-reported and genital measures of sexual arousal in men and women: A meta-analysis. *Archives of Sexual Behavior, 39*, 5–56. doi:10.1007/s10508-009-9556-9

Chivers, M. L., & Timmers, A. D. (2012). Effects of gender and relationship context in audio narratives on genital and subjective sexual response in heterosexual women and men. *Archives of Sexual Behavior, 41*, 185–197. doi:10.1007/s10508-012-9937-3

Chivers, M. L., Rieger, G., Latty, E., & Bailey, J. M. (2004). A sex difference in the specificity of sexual arousal. *Psychological Science, 15*, 736–744. doi:10.1111/j.0956-7976.2004.00750.x

Dawson, S. J., & Chivers, M. L. (2016). Gender-specificity of initial and controlled visual attention to sexual stimuli in androphilic women and gynephilic men. *PLoS One, 11*. doi:10.1371/journal.pone.0152785

Dawson, S. J., Sawatsky, M. L., & Lalumière, M. L. (2015). Assessment of introital lubrication. *Archives of Sexual Behavior, 44*, 1527–1535. doi:10.1007/s10508-015-0519-z

Freund, K., Watson, R., & Rienzo, D. (1989). Heterosexuality, homosexuality, and erotic age preference. *Journal of Sex Research, 26*, 107–117. doi:10.1080/00224498909551494

Gerritsen, J., van der Made, F., Bloemers, J., van Ham, D., Kleiverda, G., Everaerd, W., . . . Tuiten, A. (2009). The clitoral photoplethysmograph: A new way of assessing genital

arousal in women. *Journal of Sexual Medicine, 6*, 1678–1687. doi:10.1111/j.1743-6109.2009.01228.x

Hedges, L. V. (1981). Distribution theory for Glass' estimator of effect size and related estimators. *Journal of Educational Statistics, 6*, 107–128. doi:10.3102/1076998600600 2107

Huberman, J. S., & Chivers, M. L. (2015). Examining gender-specificity of sexual response with concurrent thermography and plethysmography. *Psychophysiology, 52*, 1382–1395. doi: 10.1111/psyp.12466

Huberman, J. S., Dawson, S. J., & Chivers, M. L. (2017). Examining the time course of genital and subjective sexual responses in women and men with concurrent plethysmography and thermography. *Biological Psychology, 129*, 359-369. doi:10.1016/j.biopsycho.2017. 09.006.

Janssen, E., Everaerd, W., Spiering, M., & Janssen, J. (2000). Automatic processes and the appraisal of sexual stimuli: Toward an information processing model of sexual arousal. *Journal of Sex Research, 37*, 8–23. doi:10.1080/00224490009552016

Janssen, E., Prause, N., & Geer, J. H. (2007). The sexual response. In J. T. Cacioppo, L. G. Tassinary & G. G. Berntson (Eds.), *Handbook of psychophysiology* (3rd ed.). New York, NY: Cambridge University Press.

Kinsey, A. C., Pomeroy, W. B., & Martin, C. E. (1948). *Sexual behavior in the human male*. Philadephia, PA: W. B. Saunders Company.

Laan, E. (1994). *Determinants of sexual arousal in women* (Doctoral dissertation). University of Amsterdam, Amersterdam, The Netherlands.

Laan, E., Everaerd, W., & Evers, A. (1995). Assessment of female sexual arousal: Response specificity and construct validity. *Psychophysiology, 32*, 476–485. doi:10.1111/j.1469-

8986.1995.tb02099.x

Laan, E., & Janssen , E. (2007). How do men and women feel? Determinants of subjective experience of sexual arousal. In E. Janssen (Ed.), *The psychophysiology of sex* (pp. 278-290). Bloomington: Indiana University Press.

Lalumière, M. L. (2017). On the concept of category-specificity. *Archives of Sexual Behavior*. Advanced online publication. doi:10.1007/s10508-017-0965-x

Lamprecht, V. M., & Grummer-Strawn, L. (1996). Development of new formulas to identify the fertile time of the menstrual cycle. *Contraception, 54*, 339–343. doi:10.1016/S0010-7824(96)00202-8

Levin, R. J. (2003). The ins and outs of vaginal lubrication. *Sexual and Relationship Therapy, 18*, 509–513. doi:10.1080/14681990310001609859

Levin, R. J. (2004). Measuring female genital functions—A research essential but still a clinical luxury? *Sexual and Relationship Therapy, 19*(2), 191-200. doi: 10.1080/14681990410001691406

Levin, R. J., & van Berlo, W. (2004). Sexual arousal and orgasm in subjects who experience forced or non-consensual sexual stimulation—A review. *Journal of Clinical Forensic Medicine, 11*, 82–88. doi:10.1016/j.jcfm.2003.10.008

Levin, R. J., & Wylie, K. (2008). Vaginal vasomotion—Its appearance, measurement, and usefulness in assessing the mechanisms of vasodilatation. *The Journal of Sexual Medicine, 5*, 377–386. doi:10.1111/j.1743-6109.2007.00669.x

Lykins, A. D., Cantor, J. M., Kuban, M. E., Blak, T., Dickey, R., Klassen, P. E., & Blanchard, R. (2010). Sexual arousal to female children in gynephilic men. *Sexual Abuse: A Journal of Research and Treatment, 22*, 279–289. doi:10.1177/1079063210372141

Masters, W. (1959). The sexual response cycle of the human female: Vaginal lubrication. *Annals*

New York Academy of Sciences, 83, 301-317.

Meston, C. M., & Gorzalka, B. B. (1996). The effects of immediate, delayed, and residual sympathetic activation on sexual arousal in women. *Behaviour Research and Therapy, 34*, 143–148. doi:10.1016/0005-7967(95)00050-X

O'Brien, F., & Cousineau, D. (2014). Representing error bars in within-subject designs in typical software packages. *Tutorials in Quantitative Methods for Psychology, 10(1),* 56–67.

Peterson, Z. D., Janssen, E., & Laan, E. (2010). Women's sexual responses to heterosexual and lesbian erotica: The role of stimulus intensity, affective reaction, and sexual history. *Archives of Sexual Behavior, 39,* 880–897. doi:10.1007/s10508-009-9546-y

Prause, N., & Janssen, E. (2005). Blood flow: Vaginal photoplethysmography. In I. Goldstein, C. M. Meston, S. Davis & A. Traish (Eds.), *Women's sexual function and dysfunction: Study, diagnosis and treatment* (pp. 361–369). London, UK: Taylor & Francis Medical Books.

Rieger, G., Cash, B. M., Merrill, S. M., Jones-Rounds, J., Dharmavaram, S. M., & Savin-Williams, R. C. (2015). Sexual arousal: The correspondence of eyes and genitals. *Biological Psychology, 104*, 56–64. doi:10.1016/j.biopsycho.2014.11.009

Rosen, R., Brown, C., Heiman, J., Leiblum, S., Meston, C. M., Shabsigh, R., . . . D'Adostino, R. (2000). The Female Sexual Function Index (FSFI): A multidimensional self-report intrument for the assessment of female sexual function. *Journal of Sex & Marital Therapy, 26,* 191–208. doi:10.1080/00926230600666261

Rosenthal, A. M., Sylva, D., Safron, A., & Bailey, J. A. (2012). The male bisexuality debate revisited: Some bisexual men have bisexual arousal patterns. *Archives of Sexual Behavior, 41*, 135–147.

Sakheim, D. K., Barlow, D. H., Beck, J. G., & Abrahamson, D. J. (1985). A comparison of male

heterosexual and male homosexual patterns of sexual arousal. *The Journal of Sex Research, 21,* 183–198. doi:10.1080/00224498509551257

Snowden, R. J., & Gray, N. S. (2013). Implicit sexual associations in heterosexual and homosexual women and men. *Archives of Sexual Behavior, 42*, 475–485. doi:10.1007/s10508-012-9920-z

Spape, J., Timmers, A. D., Yoon, S., Ponseti, J., & Chivers, M. L. (2014). Gender-specific genital and subjective sexual arousal to prepotent sexual features in heterosexual women and men. *Biological Psychology, 102,* 1–9. doi:10.1016/j.biopsycho.2014.07.008

Suschinsky, K. D., & Lalumière, M. L. (2011a). Prepared for anything?: An investigation of female genital arousal in response to rape cues. *Psychological Science, 22,* 159–165. doi:10.1177/0956797610394660

Suschinsky, K. D., & Lalumière, M. L. (2011b). Category-specificity and sexual concordance: The stability of sex differences in sexual arousal patterns. *The Canadian Journal of Human Sexuality, 20*, 93–108.

Suschinsky, K. D., Lalumière, M. L., & Chivers, M. L. (2009). Sex differences in patterns of genital sexual arousal: Measurement artifacts or true phenomena? *Archives of Sexual Behavior, 38,* 559–573. doi:10.1007/s10508-008-9339-8

Wiegel, M., Meston, C., & Rosen, R. (2005). The Female Sexual Function Index (FSFI): Cross-validation and development of clinical cutoff scores. *Journal of Sex & Marital Therapy, 31*, 1–20. doi:10.1080/00926230590475206

Table 2.1

Mean Within-Subject Correlations (r) and 95% CI Between Genital Responses and Three Indices of Self-Reported Sexual Arousal Across All Stimuli (top) and Sexual Stimuli Only (bottom)

		VPP	LTS
All stimuli	Continuous sexual arousal	.66 [0.34, 0.84]	.44 [0.23, 0.61]
	Post-stimulus sexual arousal	.71 [0.52, 0.83]	.45 [0.24, 0.62]
	Post-stimulus genital arousal	.74 [0.57, 0.85]	.39 [0.22, 0.53]
		VPP	LTS
Sexual stimuli only	Continuous sexual arousal	.36 [-0.05, 0.66]	.52 [0.29, 0.70]
	Post-stimulus sexual arousal	.51 [0.20, 0.72]	.57 [0.22, 0.79]
	Post-stimulus genital arousal	.52 [0.15, 0.77]	.48 [0.28, 0.65]

Table 2.2

Between-Subject Correlations (r) and 95% CI Between Genital and Self-Report Measures of Sexual Response for the Current Study and for Dawson et al. (2015)

	Lubrication		Self-reported sexual arousal		Perceived genital arousal	
	Current	Dawson	Current	Dawson	Current	Dawson
LTS	-	-	.34 [-0.21, 0.73]	.61 [0.22, 0.83]	.37 [-0.18, 0.74]	.51 [0.07, 0.78]
VPA	.05 [-0.47, 0.55]	.13 [-0.34, 0.55]	.19 [-0.36, 0.64]	.006 [-0.45, 0.46]	.08 [-0.45, 0.57]	.06 [-0.41, 0.50]

Note. Data for androphilic women only. Sexual responses were elicited via stimuli depicting male–female partnered sex.

Table 2.3

Number of Times That a Sexual Stimulus Category was Represented Within Each Rank-Preferred Category

Stimulus Type	5th		4th		3rd		2nd		1st	
	LTS	VPP	LTS	VPP	LTS	VPP	LTS	VPP	LTS	VPP
M	3	6	9	7	4	1	2	2	1	1
MM	10	8	3	5	3	2	0	0	3	3
F	2	1	4	4	5	7	3	5	5	1
FF	2	2	2	2	5	5	6	6	4	3
MF	2	1	1	0	2	3	8	4	6	10

Note. Data are based on 19 women due to a malfunction in recording the continuous self-reported sexual arousal of 1 participant. Underlined numbers represent the most frequent stimulus type in each rank-preferred category.

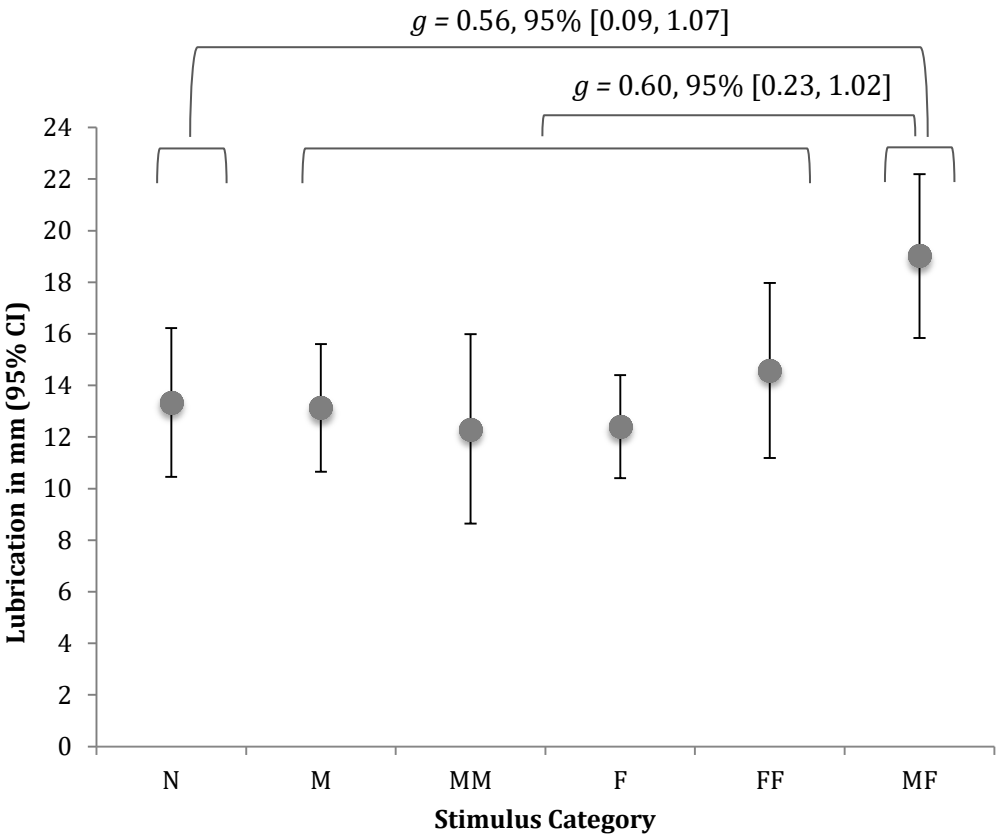

Figure 2.1. Mean lubrication (in mm) of the androphilic women (n = 17) as a function of stimulus category. Error bars represent 95% CI. N = nonsexual; M = male solitary masturbation; MM = male–male partnered sex; F= female solitary masturbation; FF = female–female partnered sex; MF = male–female partnered sex

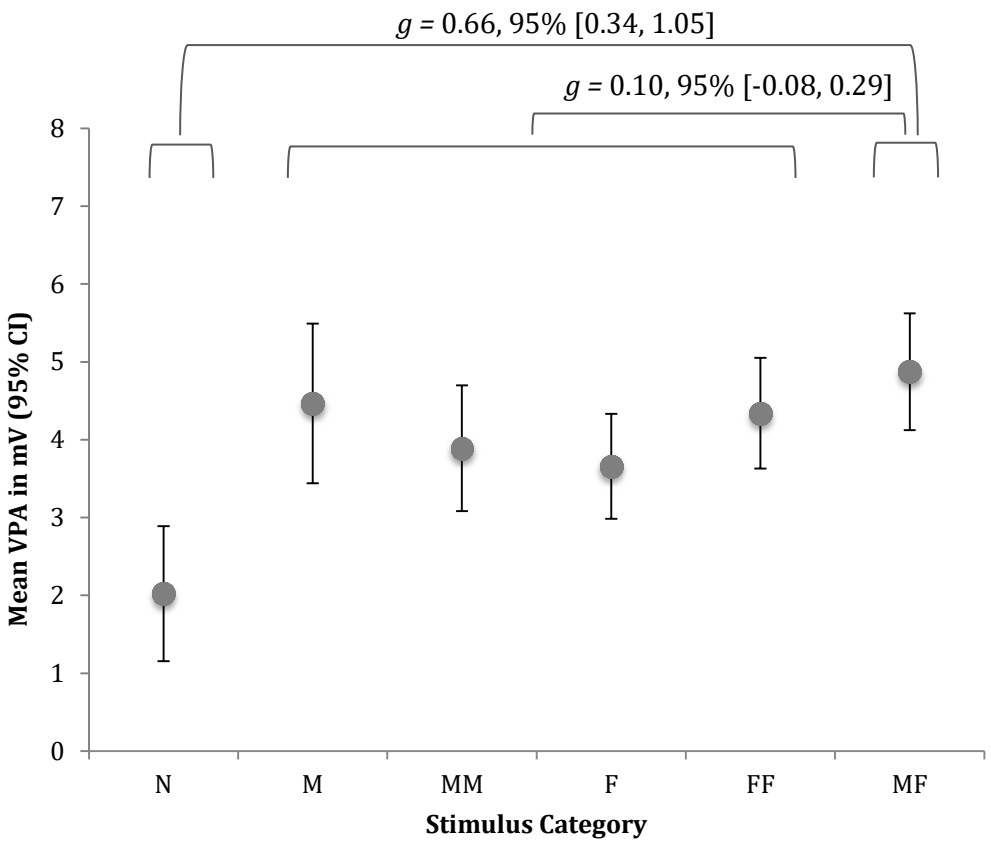

Figure 2.2. Mean VPA of the androphilic women (*n* = 17) as a function of stimulus category. Error bars represent 95% CI. N = nonsexual; M = male solitary masturbation; MM = male–male partnered sex; F= female solitary masturbation; FF = female–female partnered sex; MF = male–female partnered sex

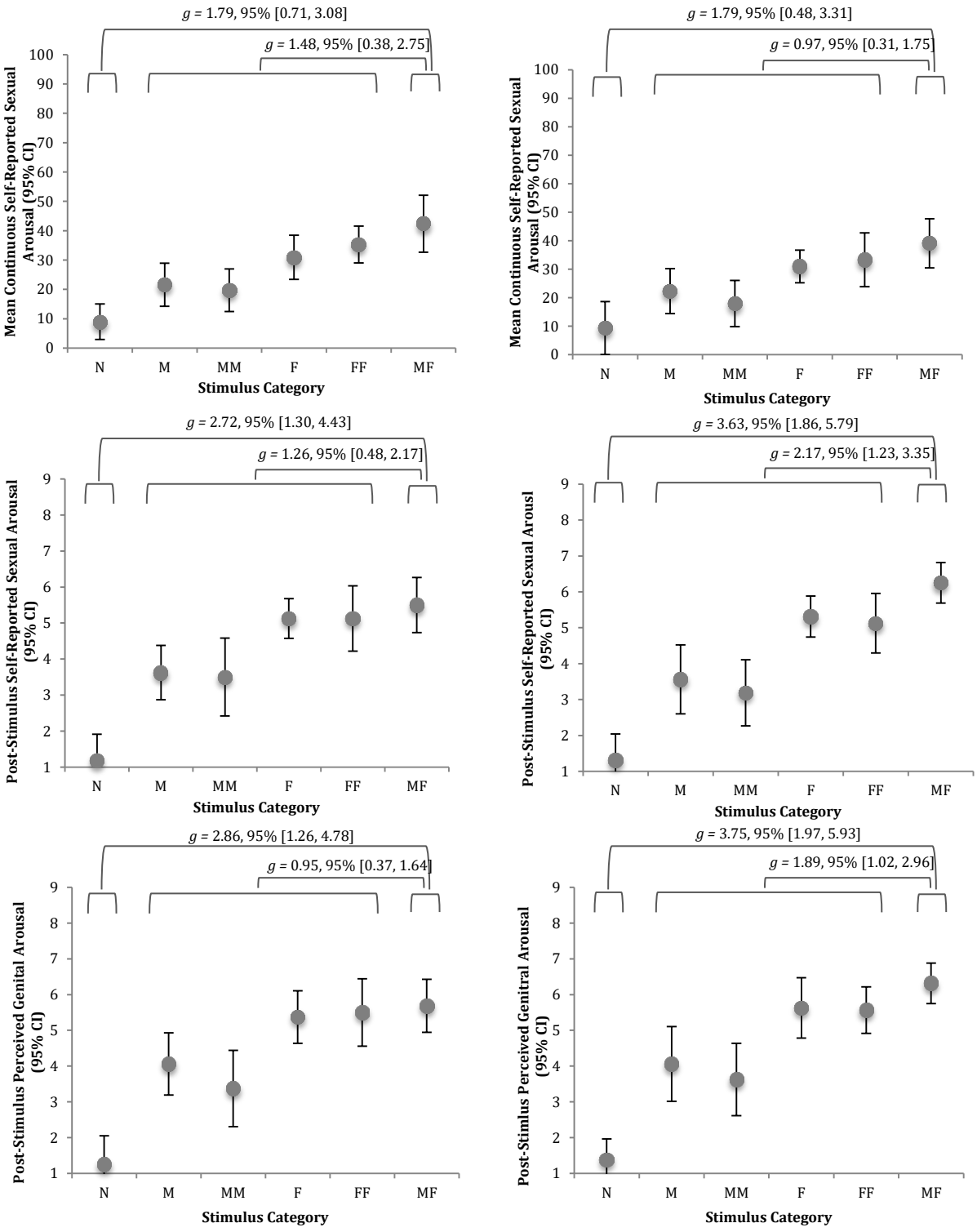

Figure 2.3. Mean continuous self-reported sexual response (top row), post-stimulus self-reported sexual response (middle row), and perceived genital response (bottom row) of the androphilic women (n = 17) as a function of stimulus category for the lubrication trials (left column) and the VPA trials (right column). Error bars represent 95% CI. N = nonsexual; M = male solitary masturbation; MM = male–male partnered sex; F= female solitary masturbation; FF = female–female partnered sex; MF = male–female partnered sex

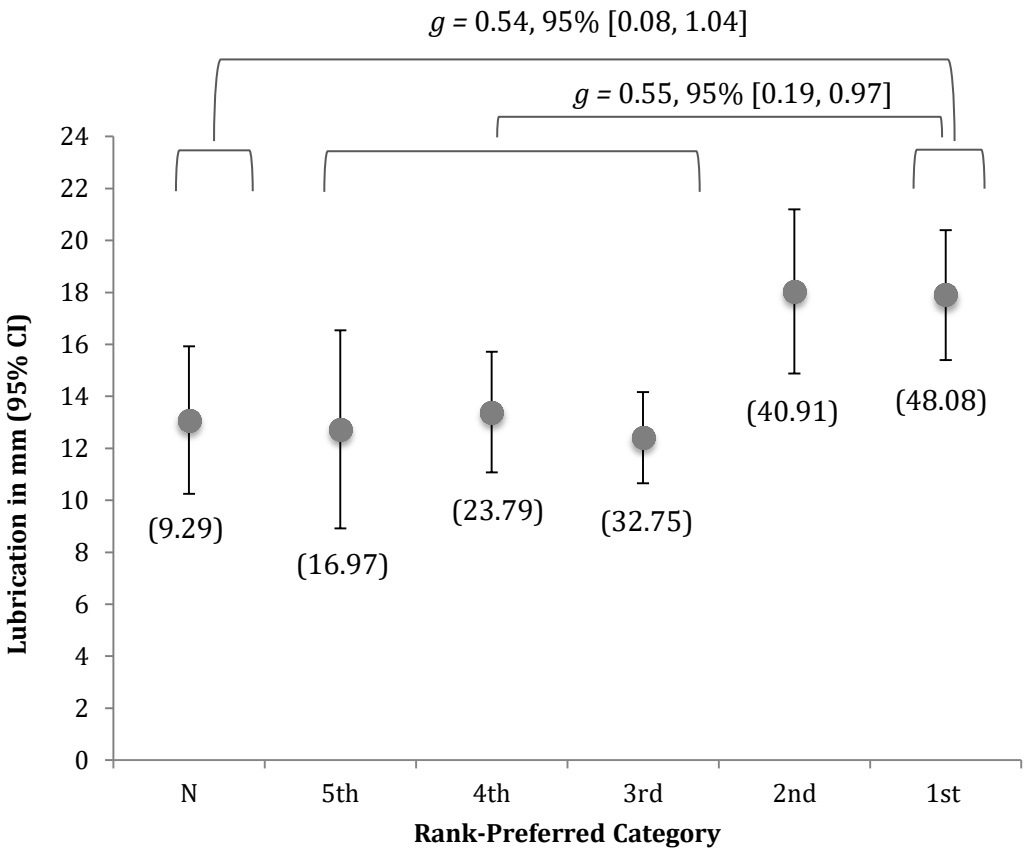

Figure 2.4. Mean lubrication of the androphilic and androgynephilic women (n = 19) as a function of rank-preferred category, where 5^{th} = least preferred and 1^{st} = most preferred sexual stimulus. Values in parentheses below data points represent the average of the mean continuous self-reported sexual arousal rating for each category. Error bars represent 95% CI.

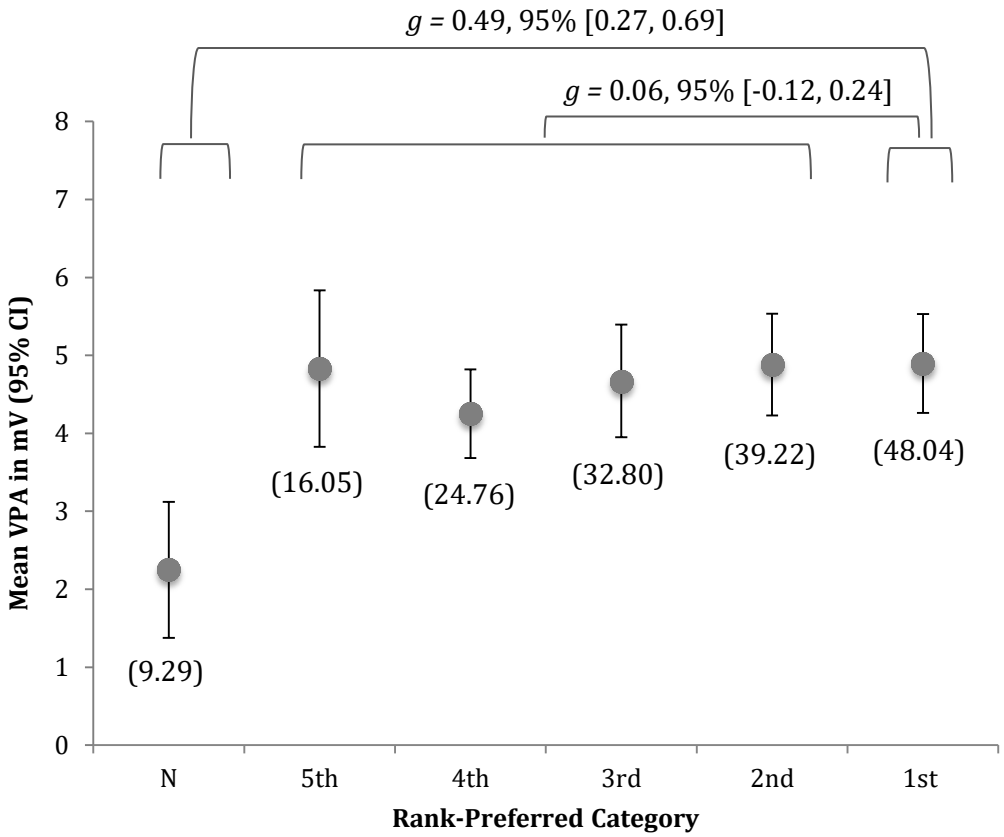

Figure 2.5. Mean VPA of androphilic and androgynephilic women (n = 19) as a function of rank-preferred category, where 5th = least preferred and 1st = most preferred sexual stimulus. Values in parentheses below data points represent the average of the mean continuous self-reported sexual arousal rating for each category. Error bars represent 95% CI.

CHAPTER 3

The Time Course of Genital Response Cue-Specificity Among Androphilic Women

Abstract

Women's genital responses measured with a vaginal photoplethysmograph (VPP) demonstrate relatively low cue-specificity for gender/sex cues—the difference in genital responses between sexual stimuli with male or female content is relatively small compared to that of men. Cue-specificity for gender/sex cues is particularly low for androphilic women. It is common practice to compare responses to sexual stimuli (typically 60–120 s film clips) using a mean or peak (highest) value. This approach overlooks the continuous and dynamic nature of sexual responding during a stimulus. Recent results suggest that cue-specificity of genital response may increase throughout the duration of a sexual stimulus. We tested this possibility in a sample of 18 androphilic women. Sexual stimuli consisted of 240 s audiovisual film clips depicting male and/or female partnered sex or solitary masturbation. Gender/sex cue-specificity, assessed using VPP, did not vary across time: The degree of cue-specificity and the magnitude of genital response were established by approximately 60–90 s and were consistent throughout the stimulus duration. Low cue-specificity for genital response was observed despite variation in self-reported sexual arousal across stimulus categories. The findings are discussed within the context of initial- and later-occurring aspects of the sexual response, according to the information processing model of sexual arousal. The results also suggest that 90–120 s stimuli are of sufficient duration to capture vaginal photoplethysmographic responses to audiovisual stimuli in sexual psychophysiological research.

Sexual responding can involve a complex interaction of physiological changes, cognitive processes, emotional expressions, and motivated behaviour (Chivers, 2005; Geer, Lapour, & Jackson, 1993; Rosen & Beck, 1988). Advances in the assessment of sexual response have allowed researchers to quantitatively assess the physiological and psychological changes that occur in response to sexual stimuli. In the laboratory, genital response is commonly assessed using measures of genital vasocongestion. Sexual stimulation can be induced using sexual images or films depicting sexual activities or audio-narratives describing sexual interactions. Using these stimulus modalities, researchers can experimentally manipulate the presentation of sexual cues, such as those depicting characteristics of the sexual target (e.g., physical sex characteristics, sexual maturation) or aspects of the sexual interaction (e.g., sexual activity type and intensity, consensual nature of the encounter, relationship context), and assess the impact of cue variations (e.g., male vs. female sexual targets) on sexual responding (e.g., Chivers, Rieger, Latty, & Bailey, 2004; Chivers, Roy, Grimbos, Cantor, & Seto, 2014; Chivers & Timmers, 2012; Lann, 1994; Laan & Everaerd, 1995; Sawatsky, Dawson, & Lalumière, 2018; Sawatsky & Lalumière, 2020; Spape, Timmers, Yoon, Ponseti, & Chivers, 2014; Suschinsky & Lalumière, 2011a, 2011b; Suschinsky, Lalumière, & Chivers, 2009).

A well-replicated difference between men and androphilic women has been observed in the degree of genital response *cue-specificity* for gender/sex cues (or gender/sex cue-specificity); by gender/sex cues we mean the genitals and secondary sex characteristics related to maleness or femaleness (sex), or the behaviours or traits associated with masculinity or femininity in a particular culture (gender) of a sexual target depicted in a sexual stimulus (van Anders, 2015, recommends the term gender/sex in contexts when gender and sex cannot be disentangled). The genital responses of both androphilic (i.e., sexually attracted to men) and gynephilic (i.e., sexually attracted to women) men tend to be elicited by gender/sex cues that correspond with

stated sexual preferences and interests (e.g., Blanchard, Klassen, Dickey, Kuban, & Blak, 2001; Freund, Watson, & Rienzo, 1989; Lykins et al., 2010; Rieger, Chivers, & Bailey, 2005; Rosenthal, Sylva, Safron, & Bailey, 2012; Sakheim, Barlow, Beck, & Abrahamson, 1985). Relative to men, the genital responses of androphilic women demonstrate much lower gender/sex cue-specificity (e.g., Chivers et al., 2004; Chivers & Bailey, 2005; Chivers, Seto, & Blanchard, 2007; Laan, Sonderman, & Janssen, 1996; Peterson, Janssen, & Laan, 2010; Suschinsky et al., 2009; reviewed by Chivers, 2017; Lalumière, Sawatsky, Dawson, & Suschinsky, 2020). In fact, androphilic women consistently show comparable genital response magnitudes to depictions of sexual activity involving men or women (e.g., Chivers et al., 2004, 2007; Suschinsky et al., 2009) and this is despite variation in self-reported sexual arousal to male versus female sexual cues (e.g., Bossio, Suschinsky, Puts, & Chivers, 2014; Chivers et al., 2004, 2007, 2014; Chivers & Timmers, 2012; Suschinsky et al., 2009). A sexual orientation difference has also emerged among women such that women reporting any degree of gynephilia show greater cue-specificity compared to exclusively androphilic women (reviewed by Chivers, 2017; for an exception see Pulverman, Hixon, & Meston, 2015, who reported gender/sex cue-specificity for genital response among androphilic but not gynephilic women).

The Multifaceted and Dynamic Nature of Sexual Response

The sexual response includes different physiological changes and the emotional experience of sexual arousal. According to the information processing model (IPM) of sexual arousal (e.g., Geer et al., 1993; Janssen, Everaerd, Spiering, & Janssen, 2000), the initial processing stage involves the automatic appraisal of cues. When a cue evokes sexual meaning in memory, this initiates a reflexive genital response (i.e., initial genital vasocongestion) and attention is captured automatically. Subsequent conscious processing of the sexual cue gives way to the self-reported experience of sexual arousal and a proliferation of genital response (Janssen

et al., 2000).

Studies of genital lubrication provide initial evidence of the differences in initial versus later-stage sexual responding, specifically as it pertains to cue-specificity. Whereas most research on cue-specificity uses measures of genital vasocongestion, such as the vaginal photoplethysmograph (VPP) or thermographic imaging of the external genitalia (e.g., Huberman & Chivers, 2015; Suschinsky et al., 2009), a recent study by Sawatsky et al. (2018) examined the effect of gender/sex cues on genital lubrication—an aspect of genital response that is thought to occur subsequent to the initial increase in vaginal vasocongestion (Levin, 2003; Masters, 1959; Masters & Johnson, 1966). Lubrication was assessed using litmus test strips (LTSs; Dawson, Sawatsky, & Lalumière, 2015) that were placed by participants at the introitus at the conclusion of each stimulus presentation. Vaginal pulse amplitude (VPA), an index of vaginal vasocongestion within the vaginal canal, was measured continuously during each stimulus presentation using the VPP. Stimuli consisted of 240-s audiovisual film clips depicting variations of male and female partnered and solitary sexual activity. Given the purported association between vaginal vasocongestion and lubrication (Levin, 2003), it was hypothesized that VPP and LTS would produce very similar response patterns.

Results for VPA replicated previous research showing low gender/sex cue-specificity (Sawatsky et al., 2018). In contrast, lubrication only increased when androphilic women were presented with stimuli depicting male–female partnered sex. The degree of lubrication to the other sexual stimulus categories was comparable to a nonsexual stimulus, suggesting that lubrication was cue-specific for male–female sex. In a separate analysis involving both androphilic and androgynephilic (sexually attracted to both men and women) women, lubrication only increased for stimuli rated as the most sexual arousing. This study was one of the first to find evidence of gender/sex cue-specificity for genital response among androphilic women.

Vaginal vasocongestion is purported to be a precursor to lubrication (Levin, 2003; Masters, 1959; Masters & Johnson, 1966), yet two studies have reported weak correlations between VPP and the LTS (Dawson et al., 2015; Sawatsky et al., 2018). A potential explanation for the weak correlations and, relatedly, the discrepancy in the degree of cue-specificity observed for VPP and LTS, is that each measure may be assessing different stages of genital response (Sawatsky et al., 2018). Lubrication may have been more cue-specific because it was measured at the end of the 240-s stimuli, unlike VPA, which was assessed continuously during the films. Moreover, VPA was averaged across the duration of each film, which fails to account for the dynamic nature of vaginal vasocongestion and the possibility that VPA may become increasingly cue-specific over time (as discussed by Sawatsky et al., 2018). Although VPA is thought to capture vasocongestion that occurs automatically and reflexively in response to any sexual stimulus (Chivers, 2005; Gerritsen et al., 2009), an IPM-derived hypothesis would suggest that further processing and elaboration of sexual cues may result in greater genital response cue-specificity over time, even when assessed using the VPP.

Sawatsky et al. (2018) proposed that cues indicating a high likelihood of sexual activity—such as the actual experience of sexual activity or viewing sexual stimuli that elicit strong feelings of sexual arousal—result in response differentiation and cue-specificity, especially under circumstances that allow for these responses to develop (i.e., longer duration stimuli). With the onset and accretion of feelings of sexual arousal, the initial increase in vaginal vasocongestion is maintained, allowing for a cascade of relatively later-stage aspects of the genital response, such as the formation of lubrication. Downstream or later-stage aspects of the genital response may be more perceptible to women (e.g., changes in lubrication, blood flow, or temperature of the external genitalia) compared to changes in the vaginal epithelium (Chivers, 2017; Chivers Seto, Lalumière, Laan, & Grimbos, 2010; Waxman & Pukall, 2009), and this

perception of genital response may have a bidirectional influence on the emotional experience of sexual arousal (Janssen et al., 2000). Indeed, there is evidence that the agreement between perceived and physiologically-measured genital response is stronger for vulvar blood flow and genital lubrication than for vasocongestion within the vaginal walls (Bouchard, Chivers, & Pukall, 2017; Bouchard, Dawson, Shelley, & Pukall, 2019; Dawson et al., 2015; Sawatsky et al., 2018). In contrast, when presented with sexual cues that indicate a low likelihood of sexual activity (e.g., viewing a non-preferred sexual target, viewing non-preferred or aversive sexual activities), the initial increase in vaginal vasocongestion assessed using VPP may dissipate with the further processing and appraisal of the sexual stimulus if given the opportunity over longer stimulus durations.

Examining vasocongestion across the duration of relatively longer-length stimuli of various sexual categories may elucidate whether cue-specificity emerges if given the opportunity. It is common practice to analyze VPA using a single peak or mean value to represent the genital response to a given stimulus (e.g., Bossio et al., 2014; Chivers & Bailey, 2005; Chivers & Timmers, 2012; Dawson, Lalumière, Allen, Vasey, & Suschinsky, 2013; Dawson, Suschinsky, & Lalumière, 2013; Heiman, 1980; Peterson et al., 2010; Rieger et al., 2005; Sawatsky et al., 2018; Spape et al., 2014; Suschinsky & Lalumière, 2011a, 2011b), which may obscure dynamic changes from being observed because it restricts the response to a single time point or an average of the response over time. Moreover, peak or mean responses are typically calculated for 60–120 s film clips (e.g., Bossio et al., 2014; Chivers et al., 2004, 2007, 2014; Sawatsky et al., 2018; Suschinsky et al., 2009), which may be too brief to allow for changes in cue-specificity to emerge.

Time Course of Sexual Response

Vaginal vasocongestion assessed using VPP occurs rapidly, within seconds of the onset

of a sexual stimulus (Huberman, Dawson, & Chivers, 2017; Laan & Everaerd, 1995; Laan & Janssen, 2007; Suschinsky, 2012). According to Levin (1980, 1992), who visually inspected VPP recordings, increases in vaginal vasocongestion can be observed within one to two seconds of sexual stimulation and precede the formation of vaginal lubrication. Vaginal lubrication is initiated 5–15 s after the onset of sexual stimulation and coalesces to cover the vaginal lumen within 10–30 s (based on observational measures; Masters, 1959; Masters & Johnson, 1966). Increases in vasocongestion assessed using VPP have also been found to precede increases in clitoral blood volume assessed using clitoral photoplethysmography (Gerritsen et al., 2009), and changes in labial temperature measured using thermography (Huberman & Chivers, 2015; Huberman et al., 2017).

Huberman et al. (2017) examined the time course of self-reported sexual arousal and of genital response assessed with VPP and thermography, as well as the dynamic relationships between these measures over time among androphilic women. The average time to onset of the initial VPA response and the average time to peak response were both approximately 20 s. Initial and peak response occurred sooner for VPA than for genital temperature and self-reported sexual arousal. VPA increased rapidly and leveled off whereas self-reported sexual arousal and genital temperature increased gradually over the 600 s film clip. VPA during the first 120 s predicted change in genital temperature throughout the trial, suggesting that early vasocongestion response is a precursor to genital temperature changes. Huberman et al. (2017) analyzed sexual responses to only one category of sexual stimuli (male masturbation) and so the results do not provide information on the nature of sexual responding to multiple categories of stimuli that differ in their sexual appeal.

Huberman et al. (2017) used data from a larger study examining gender/sex cue-specificity using 600 s masturbation films (Huberman & Chivers, 2015). Huberman and Chivers

(2015) found that for androphilic women, VPA and genital temperature did not differentiate between male and female masturbation stimuli and this response pattern did not vary across time, providing initial evidence that low cue-specificity is robust to stimulus duration. It is noteworthy, however, that women's self-reported sexual arousal in this study did not differ between male and female sexual stimuli. It is therefore unknown whether cue-specificity could emerge when androphilic women are presented with relatively longer-length sexual stimuli that elicit variation in self-reported sexual arousal. If further processing and elaboration of a sexual stimulus influences later-stage genital responding, then we would expect that genital responses to stimuli that elicit differences in self-reported sexual arousal would also differentiate over time.

Current Study

The aim of the present study was to examine the time course of vaginal vasocongestion cue-specificity for androphilic women using relatively longer duration audiovisual sexual stimuli that elicit differentiation in self-reported sexual arousal. We predicted that at the beginning of the film, VPA would increase for all sexual stimulus categories, showing an initial pattern of low cue-specificity. After the initial response, VPA would become increasingly cue-specific over time, as demonstrated by greater response variability and a larger degree of discrimination across stimulus categories. Specifically, the initial increase in VPA would be maintained for the most sexually stimulating category (presumably male–female sex), whereas VPA would decrease over time for the least sexually stimulating categories.

Method

Participants

To examine the time course of VPA, we used the Sawatsky et al. (2018) data. Prospective participants were recruited using posters on advertisement boards at a Canadian university. Posters specified that individuals 18-30 years of age were being recruited for a "sexual arousal

study." Women (n = 60) responded to the advertisements by telephone or email and received information about the study. Of these, 31 women remained interested in participating and underwent eligibility screening to ensure comfort with the experimental procedure and to maximize the likelihood of a sexual response. Eligible women were between 18 and 30 years of age and had familiarity with erotica. Women were ineligible if they had a sexually transmitted infection; were taking medication that could affect their sexual functioning, such as antidepressants (e.g., Serretti & Chiesa, 2009); had a serious mental illness or substance abuse problems; had a history of sexual dysfunction; were pregnant or trying to conceive; had never experienced vaginal penetration (e.g., from sexual activity, tampon use, or pelvic examination); or had participated in a previous study on genital lubrication in the same laboratory. Twenty-one women were eligible to participate and scheduled a laboratory session. Data from three women who did not report exclusive or predominant sexual attraction to men were excluded.

The final sample[1,2] included 18 cisgender androphilic women (*M age* = 21.6, *SD* = 3.1, range 18-28), all of whom were attending university or had completed a bachelor's degree. Most women (78%) were in a romantic relationship and reported using hormonal contraceptives at the time of testing (78%). Of the four naturally-cycling women, one was in the follicular phase of the menstrual cycle and three were in the luteal phase according to the reverse menstrual cycle day method outlined in Lamprecht and Grummer-Strawn (1996).

Measures

[1] The sample in the current study varies from Sawatsky et al. (2018) because of differences in data exclusion criteria.

[2] In the appendix (Figure 3.A1), self-report and genital response data are also presented graphically for the sample of gynephilic men (N = 9) whose data were collected for a manipulation check (Sawatsky et al., 2018). The men underwent a nearly identical experimental procedure as the women in this study and their genital responses were assessed with penile plethysmography (PPG). Visual comparison of the male PPG data and the female VPP data highlight the gender/sex difference in cue-specificity (the small male sample size precluded the formal analysis of the PPG data).

Audiovisual stimuli. The experimental stimuli consisted of six 240-s audiovisual film clips, with exemplars from six stimulus categories: nonsexual (nature documentaries); female solitary masturbation; male solitary masturbation; female–female partnered sex (oral sex and digital-vaginal penetration); male–male partnered sex (oral sex and penile-anal penetration); and male–female partnered sex (oral sex and penile-vaginal penetration). Each stimulus comprised two 120-s segments from different films. Sexual activity intensity was consistent across the duration of the stimulus (i.e., intensity did not increase over time). Two additional 60-s nonsexual film clips were used as adaptation stimuli (data not used in analyses). All stimuli were presented on a 52 cm computer monitor situated at eye-level approximately 150 cm from the participants. The participants wore noise-cancelling headphones to hear the audio component of the films.

Assessment of genital response. Changes in vaginal vasocongestion were assessed with VPP (Technische Handelsonderneming Coos, Purmerend, The Netherlands), which records VPA continuously during each film clip using Limestone Technologies Inc. (Odessa, ON, Canada) DataPac_USB and Preftest software (Version 10). VPP involves a small tampon-like acrylic device that contains an orange-red spectrum light-emitting diode and photodiode light detector. As the vaginal tissues engorge with blood they become less transparent, resulting in more light reflected back from the tissues to the probe. VPA is measured as the amplitude of each vaginal pulse and purportedly represents the phasic changes in vasocongestion associated with each heartbeat (although the precise mechanism is not well-understood; Prause & Janssen, 2005). The VPP was inserted intravaginally by the participant. A silicone anchor was attached to the cable of the VPP to ensure that the light source and receptor remained inserted to an accurate and consistent depth (i.e., 5 cm from the silicone anchor) and orientation for each participant and session. VPP is considered a sensitive measure of sexual response that is specific to sexual

stimulation (Laan, Everaerd, & Evers, 1995; Suschinsky et al., 2009). Data were sampled at a rate of 10 samples/s and band-pass filtered (0.5–10 Hz), and the amplitude of each pulse wave was recorded in millivolts (mV).

Assessment of self-reported sexual arousal. Self-reported sexual arousal was assessed continuously during each stimulus presentation. Throughout each stimulus, participants were asked to continuously rate their "*overall sexual arousal, including emotions and body sensations*" by pressing the plus ("+") and minus ("-") keys on a keypad. Pressing the plus and minus keys corresponded to the increase or decrease, respectively, of a vertical green bar on the side of the computer screen: the bar represented 0% ("*no sexual arousal*") when positioned at bottom of the screen, and 100% ("*maximum degree of sexual arousal, similar to arousal experienced before orgasm"*) when positioned at the top the screen. After each stimulus presentation, participants rated their overall sexual arousal ("*How aroused did you feel during the film*?") and perceived genital response ("*How aroused did your genitals feel during the film*?") on a 9-point Likert scale by pressing the corresponding key (1–9) on a keypad (data not used in the analyses).

Questionnaires. Participants completed a questionnaire package assessing biographical information, menstrual cycle phase, contraceptive use, sexual functioning, sexual history, and sexual interests. Degree of gynephilia and/or androphilia was assessed using a questionnaire item adapted from the Kinsey scale (Kinsey, Pomeroy, & Martin, 1948; Kinsey, Pomeroy, Martin, & Gerbhard, 1953). Women rated their sexual attraction on a 7-point scale, where 0 indicated sexual attraction exclusively to men, 3 indicated equal sexual attraction to men and women, and 6 indicated sexual attraction exclusively to women. Women were considered androphilic if they provided ratings of 0 (n = 11) or 1 (n = 7) for the Kinsey item. Seventeen androphilic women self-identified as heterosexual and 1 self-identified as bisexual.

Procedure

Prospective participants received information about the study and were screened for eligibility via telephone or email. Eligible participants scheduled an appointment at a time when they would not be menstruating and were instructed to refrain from sexual activity 24 hours prior to testing, from physical exercise 1 hour prior to testing (Meston & Gorzalka, 1996), and from using alcohol, tobacco, cold medications, and recreational drugs on the day of testing. Questionnaire responses confirmed compliance with these instructions.

At the beginning of the session, the female experimenter (either the first author or a research assistant) provided a detailed explanation of the experimental procedure and the placement of the VPP, and obtained written consent. Women were then left alone in the dimly lit room to undress from the waist down and sit comfortably in a reclining chair situated in front of the computer monitor. They were instructed to inform the experimenter once the VPP was in place and they were ready to begin the experiment. A hands-free intercom facilitated verbal communication with the experimenter. When required, the experimenter either responded using the intercom or by typing text messages that appeared on the participants' computer monitor.

Two, 60-s adaptation stimuli were presented first to allow for familiarization with the testing procedure (the procedure was identical for the adaptation and experimental trials). After the adaptation trials, women were asked (via text message) whether they had any questions or concerns before proceeding with the experiment (none responded affirmatively to this question). Next, a series of six 240-s experimental stimuli was presented, with exemplars randomly selected from each of the six stimulus categories. Stimulus order was randomized for each participant. Women were instructed to respond as naturally as possible to the films and to avoid any movements (e.g., muscles contractions, genital touching, coughing, or talking).

The interstimulus interval was 300 s in length. At 120 s, the two self-reported sexual

arousal questions were presented successively on the computer monitor and participants responded using the keypad.[3] At 180 s, the word "read" appeared on the computer monitor, signalling to women to begin reading aloud from a magazine (with no sexual content). The purpose of this distraction task was to provide the opportunity for genital responses to return to baseline. Women ceased reading at 275 s when they heard a ringing bell via the headphones (i.e., participants read for 95 s). They were then instructed (via a text message) to move the green bar to a level representative of their current degree of self-reported sexual arousal. Once the green bar was in a stable position (no movement for approximately 3 s), the next film started. As women viewed the film, they were instructed to continuously rate their self-reported sexual arousal.

Genital lubrication was assessed with LTSs using a nearly identical procedure (order of the LTS and VPP conditions was counterbalanced across participants); the LTS data are not analyzed here but are reported elsewhere (see Sawatsky et al., 2018). The questionnaire package was completed between the LTS and VPP portions of the session. At the end of the entire experiment, women were debriefed about the purpose of the study. The sessions were approximately 3.5 hours and the compensation was $60 CND. The university's Research Ethics and Integrity Board reviewed and approved all experimental procedures in accordance with the ethical guidelines of the Canadian Tri-Council Policy Statement.

Data Analysis

Data preparation. Prior to data analysis, movement artifacts in the VPP data (i.e., large, abrupt changes in amplitude) were identified by visual inspection of the waveform and were manually removed. Of the 1440, 15-s epochs (16 non-overlapping time intervals for each sexual

[3] In Sawatsky et al. (2018), the self-reported sexual arousal questions were presented 120 s after the conclusion of each film for consistency with the experimental procedure for the LTS trials.

stimulus presentation across all participants), 54 epochs (or 3.8%) contained movement artifacts; the average time removed per affected epoch was 2.0 s (median = 1.5 s; range 1.5–7.5 s). When a movement artifact was identified and removed, VPA for that second was replaced by the value of the last valid data point. When a movement artifact affected a trial baseline, the trial baseline was replaced by the average of all other trial baselines for that participant; this occurred for two women (one trial for one woman, three trials for the other woman).

VPA outliers were defined as values greater than 2.58 standard deviations from the mean for a given epoch (Tabachnick & Fidell, 2007). For one woman, an outlier was identified for one epoch; inclusion of her data did not affect the pattern of results. For another woman, an outlier was identified for all epochs of the male masturbation stimulus. When this participant was removed from analyses, the overall aggregate pattern of results for cue-specificity were not impacted; however, a small intensity effect emerged for some epochs, such that all partnered sex stimuli elicited a stronger genital response compared to male masturbation. Data from these two women were retained for analyses because removing or modifying outliers reduces individual variability. Some degree of skewness and kurtosis was observed, which was expected given the relatively small sample. No data transformations were applied in order to maintain the original scale for VPA.

Genital response and self-report arousal data were averaged for each 15-s epoch, resulting in 16 non-overlapping epochs per stimulus. Averaging responses across 15-s epochs is consistent with previous research (Huberman & Chivers, 2015) and doing so resulted in a reasonable number of data points to perform the analyses. The trial baseline was subtracted from the average response for each epoch (mean-minus-baseline). Mean-minus-baseline (MMB) is presented because it is most commonly reported in psychophysiology studies (e.g., Chivers et al., 2007).

Cue-specificity can be understood (and operationalized) as the degree of preference (in terms of genital or self-reported responses) for a particular stimulus category relative to others, or as the extent to which response magnitudes vary across stimulus categories. We used three indices to capture the degree of response discrimination. The *stimulus index* and *preference index* both represented the degree to which a particular sexual stimulus category elicited a higher response than the other sexual stimulus categories. The *variability index* reflected the degree of response variation across all sexual stimulus categories. The three indices were calculated within-subjects for each 15-s epoch, producing 16 data points per index per participant.

The stimulus index was examined by calculating the difference in mean-minus-baseline VPA between the sexual stimulus category that elicited the largest increase in VPA during an epoch for a given participant and the average of her responses to the other sexual stimulus categories during that same epoch. A higher stimulus index score represented greater discrimination between the sexual stimulus category that elicited the greatest response compared to the other sexual categories. The preference index was examined by calculating the difference in mean-minus-baseline VPA between the most preferred and least preferred sexual stimulus categories for a given participant. Stimulus preference was determined based on each woman's self-reported sexual arousal ratings during the final epoch: The sexual stimuli that elicited the highest and lowest self-reported sexual arousal ratings during the final epoch were considered the most and least preferred stimulus categories, respectively (stimulus preference was determined separately for each woman). Male–female partnered sex was most frequently identified as the most preferred stimulus (n = 7) and male–male partnered sex was most frequently identified as least preferred stimulus (n = 10). A preference index score of zero represented no discrimination in VPA between the most and least preferred sexual stimulus categories. Analyses involving the preference index were based on 17 women because data were

missing for one woman who forgot to rate her continuous self-reported sexual arousal. For another woman, two films were identified as eliciting the lowest self-reported sexual arousal ratings; as such, VPA for these two films was averaged to produce a single value that represented her response to the least preferred stimulus. Lastly, the variability index was examined by calculating the standard deviation (*SD*) of genital responses across all five sexual stimulus categories for each participant. A higher value represented greater response variability across sexual stimulus categories for a given epoch.

Analysis. Within-subjects analyses of variance (ANOVAs) were calculated to examine the effect of time (independent variable; IV) on each of the three indices of cue-specificity (dependent variables; DVs) and to assess trends across time (separate analyses for each index). To further examine differentiation in VPA across the sexual stimulus categories over time, within-subjects ANOVAs were calculated with sexual stimulus category and time as the IVs and mean-minus-baseline VPA as the DV. Post-hoc one-way within-subjects ANOVAs were performed to investigate potential differences in VPA (DV) across stimulus categories (IV) at different time points.

We present the *F*-statistic and the partial eta-squared (η_p^2) effect size with a 90% confidence interval (CI). The CIs for η_p^2 were calculated using the Smithson (2001) script (Smithson, n.d.). A 90% CI is appropriate for one-sided statistics that do not have negative values, such as η_p^2 (Lakens, 2013). Greenhouse-Geisser corrections were applied when the assumption of sphericity was violated.

For pairwise comparisons, the effect size Hedge's *g* is presented because it is considered more appropriate than Cohen's *d* when sample sizes are relatively small (< 20; Borenstein, Hedges, Higgins, & Rothstein, 2009). Hedge's *g* is a corrected form of *d* and can be interpreted as such. For each comparison, Hedge's *g* represents the size of the difference between the two

within-subjects variables of the conditions being compared and is presented with its 95% CI. The 95% CI is more appropriate for *g* because values can be both positive and negative. Hedge's *g* and its CI were calculated using the method outlined in Borenstein et al. (2009). In the Figures, the stimulus index, the preference index, and the variability index were averaged across participants for each epoch. The error bars represent 95% CI and were calculated using the O'Brien and Cousineau (2014) method.

Manipulation Check

We sought to examine potential changes in VPA cue-specificity across time using sexual stimulus categories that elicited different degrees of self-reported sexual arousal. Figure 3.1 (top) displays changes in self-reported sexual arousal across stimulus categories (the nonsexual category is presented for visual comparison) for 17 women (data are missing for the woman who forgot to rate her continuous self-reported sexual arousal). A 5 (sexual stimulus category) x 16 (epoch/time) within-subjects ANOVA was conducted to verify the differential effects of sexual stimulus categories on women's self-reported sexual arousal (DV). The results showed an interaction between stimulus category and time $F(2.55, 40.83) = 4.62$, $\eta_p^2 = 0.22$, 90% CI [0.03, 0.36].

A one-way within-subjects ANOVA with sexual stimulus category as the IV showed no difference in self-reported sexual arousal (DV) at the first epoch (0–15 s), $F(1.16, 18.56) = 0.30$, $\eta_p^2 = 0.02$, 90% CI [0.00, 0.18], whereas differentiation across sexual stimulus categories was observed at the final epoch (226–240 s), $F(4, 64) = 6.31$, $\eta_p^2 = 0.28$ [0.10, 0.38]. Pairwise comparisons were used to compare sexual arousal to stimulus categories of the same intensity at the final epoch. For partnered sex stimuli, male–female sex and female–female sex were rated as more sexually arousing than male–male sex: $g = 1.16$, 95% CI [0.26, 2.21], and, $g = 1.44$ [0.40, 2.67], respectively. Sexual arousal ratings were higher for male–female sex versus female–

female sex, g = 0.28 [-0.18, 0.78], and for female masturbation versus male masturbation, g = 0.39 [-0.17, 1.02], but the confidence intervals included 0. Thus, the degree of women's self-reported sexual arousal differed across some stimulus categories. Cue-specificity for self-reported sexual arousal was observed for stimuli with a female actor and this effect was especially pronounced for stimuli portraying partnered sex.

Results

Time Course of Cue-Specificity

Figure 3.2 displays the stimulus index, preference index, and the variability index—the three indices of cue-specificity—for VPA across the entire stimulus duration (240 s). Results of the one-way within-subjects ANOVA with the stimulus index as the DV and time (16 epochs) as the IV showed a main effect of time, $F(4.47, 76.06) = 4.01$, $\eta_p^2 = 0.19$, 90% CI [0.04, 0.28]. The stimulus index increased linearly over the duration of the stimuli $F(1, 17) = 8.44$, $\eta_p^2 = 0.33$ [0.05, 0.54], indicating an overall steady increase in specificity for the stimulus that elicited the largest increase in VPA. There were no quadratic or cubic trends. For the preference index, there was no effect of time, $F(4.22, 67.61) = 0.78$, $\eta_p^2 = 0.05$ [0.00, 0.09], meaning that the difference in VPA between the most and least preferred stimulus categories was stable across the entire stimulus duration. For the variability index, there was a main effect of time, $F(2.98, 50.65) = 6.25$, $\eta_p^2 = 0.27$ [0.08, 0.38]. Both linear, $F(1, 17) = 9.24$, $\eta_p^2 = 0.35$ [0.06, 0.55], and quadratic, $F(1, 17) = 9.33$, $\eta_p^2 = 0.35$ [0.06, 0.56], trends were observed, reflecting an initial increase and subsequent levelling off the variability in VPA across stimulus categories.

To test our prediction that cue-specificity would become more differentiated over time (i.e., low to high), we examined the stimulus index and the variability index (DVs) for epochs before and after 60 s and 90 s (the preference index was not included in this set of analyses because no effect of time was observed). These time points were selected because many studies

employing VPP to assess genital response have analyzed mean VPA for 60 s or 90 s film clips. Also, visual inspection of Figures 3.1 and 3.2 in the current study, as well as the figures in Huberman et al. (2017), show a levelling off of genital responses and of the degree of cue-specificity after approximately 60–90 s.

Initial cue-specificity. A one-way within-subjects ANOVA with the stimulus index as the DV showed no effect of time from 0–60 s (four epochs), $F(2.12, 36.03) = 2.04$, $\eta_p^2 = 0.11$, 90% CI [0.00, 0.24]. The effect of time increased when considering 0–90 s (six epochs), $F(2.47, 41.91) = 3.82$, $\eta_p^2 = 0.18$ [0.02, 0.32], and a linear trend was observed, $F(1, 17) = 6.87$, $\eta_p^2 = 0.29$ [0.03, 0.50]. When analyzing the variability index between 0–60 s, there was a main effect of time, $F(1.60, 27.17) = 4.03$, $\eta_p^2 = 0.19$ [0.01, 0.37], with a linear trend, $F(1, 17) = 6.09$, $\eta_p^2 = 0.26$ [0.02, 0.48]. The effect of time on the variability index was stronger when analyzing 0–90 s, $F(2.28, 38.70) = 7.78$, $\eta_p^2 = 0.31$ [0.10, 0.45], as was the linear trend, $F(1, 17) = 13.37$, $\eta_p^2 = 0.44$ [0.13, 0.62].

Later cue-specificity. To examine potential changes in degree of cue-specificity after the initial increase in genital response, we analyzed the 12 epochs between 61–240 s and the 10 epochs between 91–240 s. There was no effect of time on the stimulus index after 60 s, $F(4.30, 73.10) = 0.71$, $\eta_p^2 = 0.04$, 90% CI [0.00, 0.08], or after 90 s, $F(3.94, 67.03) = 0.58$, $\eta_p^2 = 0.03$ [0.00, 0.07]. There was also no effect of time on the variability index after 60 s, $F(4.13, 70.24) = 1.58$, $\eta_p^2 = 0.09$ [0.00, 0.15], or after 90 s, $F(3.59, 61.06) = 1.48$, $\eta_p^2 = 0.08$ [0.00, 0.16]. Thus, the degree of specificity for a particular stimulus category and the degree of variation across sexual stimulus categories did not increase across the entire stimulus duration, but rather were established by approximately 60–90 s and remained stable thereafter.

Time Course of VPA for Stimulus Categories

To investigate the effect of time on VPA in response to each sexual stimulus category, a

5 (sexual stimulus category) x 16 (epoch/time) within-subjects ANOVA was conducted using mean-minus-baseline VPA as the DV. There was a main effect of time when examining the entire 240 s stimulus duration, $F(2.63, 44.69) = 14.93$, $\eta_p^2 = 0.47$, 90% CI [0.26, 0.58], but no main effect of sexual stimulus category, $F(4, 68) = 2.03$, $\eta_p^2 = 0.11$ [0.00, 0.19]. There was no interaction between time and sexual stimulus category, $F(6.64, 112.88) = 1.89$, $\eta_p^2 = 0.10$ [0.00, 0.15], showing that the VPA trajectory across time was similar for all stimuli. VPA increased linearly, $F(1, 17) = 23.58$, $\eta_p^2 = 0.58$ [0.27, 0.72], and quadratically over time, $F(1, 17) = 15.71$, $\eta_p^2 = 0.48$ [0.16, 0.65], indicating that VPA initially increased and subsequently plateaued. Figure 3.1 (bottom) presents change in VPA (mean-minus-baseline) for each stimulus category across the duration of the stimuli. VPA for the nonsexual stimulus category is presented for visual comparison.

Visual inspection of Figure 3.1 (bottom) shows that VPA plateaued after approximately 60–90 s. When examining 61–240 s, there was a main effect of time, $F(4.09, 69.54) = 3.06$, $\eta_p^2 = 0.15$, 90% CI [0.01, 0.24], but the effect size was much smaller compared to when the entire 240 s was analyzed. The size of the linear effect of time decreased, $F(1, 17) = 5.43$, $\eta_p^2 = 0.24$ [0.01, 0.46], and the quadratic trend was no longer detected. There was no effect of stimulus category and no interaction between stimulus category and time. When analyzing 91–240 s, there was no longer an effect of time, $F(3.83, 65.59) = 2.47$, $\eta_p^2 = 0.13$ [0.00, 0.21], no effect of stimulus category, and no interaction. Thus, the initial increase in VPA levelled off between 60–90 s and this pattern was similar for all sexual stimulus categories.

Additional one-way ANOVAs were performed to further examine the effect of sexual stimulus category (IV) on VPA (DV) at select time points. VPA did not differ across sexual stimulus categories at the 61–75 s epoch, $F(4, 68) = 1.49$, $\eta_p^2 = 0.08$, 90% CI [0.00, 0.15], the 91–105 s epoch, $F(4, 68) = 1.99$, $\eta_p^2 = 0.11$ [0.00, 0.18], or the final epoch (226-240 s), $F(4, 68)$

= 2.08, η_p^2 = 0.11 [0.00, 0.19].

Subsidiary Analyses

For comparison with VPP data, subsidiary analyses were performed to examine the time course of the stimulus index, preference index, and variability index for continuous self-reported sexual arousal (see Figure 3.3). Unlike VPA, the stimulus index for self-reported sexual arousal continued to increase after 60 s, $F(2.46, 39.35) = 8.36$, $\eta_p^2 = 0.34$, 90% CI [0.12, 0.47], and after 90 s, $F(2.27, 36.28) = 7.41$, $\eta_p^2 = 0.32$ [0.09, 0.46]. Similarly, the variability index for self-reported sexual arousal continued to increase after 60 s, $F(2.84, 45.46) = 15.53$, $\eta_p^2 = 0.49$ [0.28, 0.59], and after 90 s, $F(2.19, 35.06) = 15.56$, $\eta_p^2 = 0.49$ [0.26, 0.61]. The preference index (calculated based on the difference in self-reported sexual arousal between the most and least sexually arousing films) also increased across stimulus duration, $F(2.24, 35.89) = 18.93$, $\eta_p^2 = 0.54$ [0.32, 0.65].

Discussion

This study examined the time course of androphilic women's genital responses assessed using vaginal photoplethysmography across various categories of 240-s sexual film clips (male and/or female partnered or solitary sex) in order to investigate potential changes in the degree of gender/sex cue-specificity for vaginal vasocongestion. Three indices of response discrimination were calculated to examine cue-specificity. Using three indices allowed us to test our hypotheses using multiple definitions or operationalizations of the concept of cue-specificity. The stimulus index assessed the degree to which responses were greater for the stimulus that evoked the largest increase in vaginal vasocongestion relative to the other sexual stimulus categories; the preference index assessed the degree of response discrimination between the most and least preferred stimulus categories, according to self-reported sexual arousal; and the variability index was a measure of response variability across sexual stimulus categories.

The stimulus index and variability index showed a small increase in the cue-specificity of VPA at the onset of the stimuli, which plateaued after approximately 60–90 s and remained stable across the stimulus duration. The preference index did not vary across time, meaning that the degree of response discrimination between the most and least preferred stimuli was stable across the entire stimulus duration. The results did not support our hypothesis that vaginal vasocongestion would become increasingly differentiated and more cue-specific over time. Further, low cue-specificity for vaginal vasocongestion was observed despite a continual increase in the degree of cue-specificity for self-reported sexual arousal.

When examining the trajectory of responses to the sexual stimulus categories, an initial increase in vaginal vasocongestion was observed in response to all sexual stimuli. By approximately 60–90 s, the magnitude of vaginal vasocongestion appeared to be established for all sexual stimuli, reflected by a levelling off of VPA for the remainder of the film clips. Despite being rated as the most sexually arousing, on average, male–female partnered sex did not exhibit a unique trajectory across time, as indicated by the lack of interaction between time and stimulus category.

The results suggest that low gender/sex cue-specificity is robust to stimulus duration for androphilic women when genital responses are assessed using vaginal photoplethysmography. This finding adds to the existing body of research in which a number of experimental variables have been manipulated in order to test and attempt to explain low gender/sex cue-specify for androphilic women (reviewed by Lalumière et al., 2020). Low gender/sex cue-specificity for androphilic women has been observed with various stimulus modalities (e.g., audiovisual film clips, audio-narratives, still images) using different measures of genital vasocongestion (e.g., clitoral plethysmography, Suschinsky, Dawson, & Chivers, 2020; labial and clitoral thermography, Huberman & Chivers, 2015). Variations of other sexual cues also produce low

cue-specificity despite eliciting differences in self-reported sexual arousal (e.g., depictions of consensual vs. nonconsensual sex, Suschinsky & Lalumière, 2011a, 2011b). Vaginal response magnitude is affected by some contextual cues, such as sexual activity type (Chivers et al., 2014) and intensity (e.g., Chivers et al., 2007; c.f. current study and Bouchard et al., 2017), and relationship context (Chivers & Timmers, 2012). Importantly, when differentiation in VPA does occur in response to different sexual cues, responses to less- or non-preferred sexual stimuli (e.g., nonhuman primates, Chivers & Bailey, 2005) are higher compared to nonsexual stimuli; this is not always the case for men.

Only a few studies have found gender/sex cue-specificity for androphilic women using vaginal photoplethysmography. In two studies, gender/sex cue-specificity was observed with sexual stimuli containing minimal contextual cues—still images of aroused genitals (Spape et al., 2014) and still images of nude individuals varying in attractiveness (Timmers, 2019). These results highlight the relevance of contextual cues on vaginal vasocongestion; however, removing contextual cues may not be ecologically valid. Sexual attraction and arousal are organized around a complexity of features associated with sex and gender, beyond simply genital morphology (van Anders, 2015). In another study, gender/sex cue-specificity was found using a novel analytic technique (smoothing regression splines; Pulverman et al., 2015); however, the main effect of stimulus category (male–female, male–male, female–female) on vaginal vasocongestion was very small ($R^2 = .003$ for androphilic women) and this was despite a relatively strong effect of stimulus category on self-reported sexual arousal ($\eta^2 = .61$). Taken together, there is strong evidence that vaginal vasocongestion assessed with VPP demonstrates a pattern of low cue-specificity for gender/sex cues, particularly among androphilic women presented with stimuli containing a relatively complex array of contextual cues (e.g., audiovisual or narrative stimuli), and this response pattern is highly distinguishable from that of men who

demonstrate much higher gender/sex cue-specificity (Figure 3.A1 in the appendix depicts the time course of men's penile responses to gender/sex cues).

Sawatsky et al. (2018) hypothesized that higher gender/sex cue-specificity might emerge for vaginal vasocongestion if given the opportunity with longer duration stimuli, consistent with the observation that genital lubrication assessed at the conclusion of 240 s stimuli was specific to stimuli rated as the most sexually arousing (e.g., male–female partnered sex for androphilic women). It follows that if vaginal vasocongestion were a precursor to lubrication, then cue-specificity may increase across stimulus duration, with higher VPA observed at the conclusion of the most sexually arousing stimuli. The results of the current study, however, do not support the Sawatsky et al. prediction: The magnitude of VPA was similar at the conclusion of all 240 s sexual stimuli and this was despite discrimination in self-reported sexual arousal.

The observation that the magnitude of VPA stabilized after approximately 60–90 s validates the use of 90 s audiovisual stimuli in VPP research, at least when participants are fairly young without a history of sexual dysfunction. Huberman et al. (2017) also noted that VPA plateaued following a quick initial response and although they did not report on the timeline of this observation, visual inspection of their figures shows a levelling off at approximately 90 s. Other research has shown longer latency to maximum response or plateau: Polan et al. (2003) reported that the time required to reach what they referred to as "asymptotic" (maximal) VPA was approximately 120 s, and visual inspection of figures in Laan et al. (1995) show levelling of VPA after approximately 150 s. Differences in time to reach maximum responding are likely attributed to differences in stimulus content. The stimuli used by Polan et al. and Laan et al. included a progressive sequence of sexual activity intensity (flirtation, non-intercourse sexual activities, intercourse), whereas sexual activity intensity in Huberman et al. and the current study was consistent across stimulus duration. The results of the current study replicate previous

research showing that VPA tends to increase rapidly and then level off, and extends this observed trajectory to various categories of sexual stimuli that elicit different degrees of self-reported sexual arousal.

We decided to investigate the time course of cue-specificity by analyzing the VPP data from the Sawatsky et al. (2018) study in order to compare and contrast the VPA findings with those observed for LTS. In doing so, we were limited by the parameters of the Sawatsky et al. study. Future research would benefit by increasing the sample size and including women with different degrees of same- and other-sex sexual attraction. Low cue-specificity for VPA is a robust finding among androphilic women, but there is evidence to suggest that women with any degree of gynephilia show greater cue-specificity for female gender/sex cues (e.g., Bouchard, Timmers, & Chivers, 2015; reviewed by Chivers, 2017). Rieger et al. (2015) investigated gender/sex cue-specificity among men and women with different degrees of same- and opposite sexual attraction according to responses on a Kinsey-type scale (Kinsey et al., 1948, 1953) and found that homosexual women (authors' terminology; rating of 5 or 6 on the 6-point Kinsey scale) were somewhat more cue-specific than heterosexual women (rating of 0 or 1), but the degree of cue-specificity was weaker for all women compared to men, regardless of sexual orientation. Rieger et al. (2015) analyzed mean-minus-baseline responses, averaging across the 180-s stimuli (male or female masturbation); if response differentiation emerges for women with gynephilic sexual attractions following an initial automatic and indiscriminate response to a wide range of cues, then averaging responses could obscure potential differences between stimuli, accounting for the lower cue-specificity observed for homosexual women compared to men. Research investigating the time course of gender/sex cue-specificity for VPA among women with different degrees of gynephilia and androphilia would elucidate when (and if)

differentiation occurs and whether low cue-specificity for gender/sex cues is indeed a phenomenon exclusive to androphilic women.

The results of the current study indicate that low gender/sex cue-specificity for androphilic women is not limited to the initial phase of the vaginal vasocongestion response, but rather is sustained across stimulus duration. VPA showed a rapid, initial response at the onset of sexual stimulation that plateaued by 60–90 s, regardless of stimulus content (e.g., gender/sex or intensity cues). An initial rapid and indiscriminate increase in vaginal vasocongestion may be required to initiate downstream, later-occurring aspects of the genital response. The initial magnitude of the increase in vaginal vasocongestion was sustained across stimulus duration—even though self-reported sexual arousal continued to increase over time and to differentiate across stimulus categories—suggesting that vaginal vasocongestion is more akin to an on/off switch that responds to the presentation of any sexual cue. According to the IPM (Geer et al., 1993; Janssen et al., 2000), later-occurring genital changes (e.g., genital lubrication, engorgement of external genitalia) may be more discriminant, reflecting a proliferation of genital response that is more strongly related to the emotional experience of sexual arousal and, in this sense, more affected by specific features of a sexual target or experience. The lubrication results in Sawatsky et al. (2018) are consistent with this suggestion. The differences in gender/sex cue-specificity that have been observed for early- versus later-stage attentional processing (Dawson & Chivers, 2016, 2018, 2019) may be responsible for potential differences in cue-specificity for initial and later-occurring genital changes (Chivers, 2017).

Research on the time course of different aspects or stages of the genital response (e.g., clitoral vasocongestion assessed with clitoral photoplethysmography, vulvar blood flow assessed with laser Doppler imaging) will clarify the time course of these processes and whether low gender/sex cue-specificity is exclusive to vaginal vasocongestion. It is recommended that cue-

specificity research include sexual stimulus categories that elicit different degrees of self-reported sexual arousal in order to rule out that low cue-specificity for genital response is caused by a lack of differentiation in the experience of sexual arousal. Analyses using multilevel modeling (e.g., Huberman et al., 2017) may be useful to closely examine individual variation in response patterns. Using the IPM as a framework, future research can integrate the concurrent measurement of various aspects of the sexual response (genital, attentional, affective) to examine their relative inputs and responsivity to different cues, thereby elucidating the multifaceted and dynamic nature of the female sexual response.

References

Blanchard, R., Klassen, P., Dickey, R., Kuban, M. E., & Blak, T. (2001). Sensitivity and specificity of the phallometric test for pedophilia in nonadmitting sex offenders. *Psychological Assessment, 13*, 118–126. doi:10.1037//1040-3590.13.1.118

Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2009). *Introduction to meta-analysis*. West Sussex, UK: John Wiley & Sons, Ltd.

Bossio, J. A., Suschinsky, K. D., Puts, D. A., & Chivers, M. L. (2014). Does menstrual cycle phase influence the gender specificity of heterosexual women's genital and subjective sexual arousal? *Archives of Sexual Behavior, 43*, 941–952. doi:10.1007/s10508-013-0233-7

Bouchard, K. N., Chivers, M. L., & Pukall, C. F. (2017). Effects of genital response measurement device and stimulus characteristics on sexual concordance in women. *The Journal of Sex Research, 54*, 1197-1208. doi:10.1080/00224499.2016.1265641

Bouchard, K. N., Dawson, S. J., Shelley, A. J., & Pukall, C. F. (2019). Concurrent measurement of genital lubrication and blood flow during sexual arousal. *Biological Psychology, 145*, 159–166. doi:10.1016/j.biopsycho.2019.05.003

Bouchard, K. N., Timmers, A. D., & Chivers, M. L. (2015). Gender-specificity of genital response and self-reported sexual arousal in women endorsing facets of bisexuality. *Journal of Bisexuality, 15*, 180-203. doi:10.1080/15299716.2015.1022924

Chivers, M. L. (2005). A brief review and discussion of sex differences in the specificity of sexual arousal. *Sexual and Relationship Therapy, 20*, 377–390. doi:10.1080/14681990500238802

Chivers, M. L. (2017). The specificity of women's sexual response and its relationship with sexual orientations: A review and ten hypotheses. *Archives of Sexual Behavior, 46*, 1161–

1179. doi:10.1007/s10508-016-0897-x

Chivers, M. L., & Bailey, J. M. (2005). A sex difference in features that elicit genital response. *Biological Psychology, 70*, 115–120. doi:10.1016/ j.biopsycho.2004.12.002

Chivers, M. L., Roy, C., Grimbos, T., Cantor, J. M., & Seto, M. C. (2014). Specificity of sexual arousal for sexual activities in men and women with conventional and masochistic sexual interests. *Archives of Sexual Behavior, 43*, 931–940. doi:10.1007/s10508-013-0174-1

Chivers, M. L., Seto, M. C., & Blanchard, R. (2007). Gender and sexual orientation differences in sexual response to sexual activities versus gender of actors in sexual films. *Journal of Personality and Social Psychology, 93*, 1108–1121. doi:10.1037/0022-3514.93.6.1108

Chivers, M. L., Seto, M. C., Lalumière, M. L., Laan, E., & Grimbos, T. (2010). Agreement of self-reported and genital measures of sexual arousal in men and women: A meta-analysis. *Archives of Sexual Behavior, 39*, 5–56. doi:10.1007/s10508-009-9556-9

Chivers, M. L., & Timmers, A. D. (2012). Effects of gender and relationship context in audio narratives on genital and subjective sexual response in heterosexual women and men. *Archives of Sexual Behavior, 41*, 185–197. doi:10.1007/s10508-012-9937-3

Chivers, M. L., Rieger, G., Latty, E., & Bailey, J. M. (2004). A sex difference in the specificity of sexual arousal. *Psychological Science, 15*, 736–744. doi:10.1111/j.0956-7976.2004.00750.x

Dawson, S. J., & Chivers, M. L. (2016). Gender-specificity of initial and controlled visual attention to sexual stimuli in androphilic women and gynephilic men. *PloS ONE, 11*(5), e0155651. doi:10.1371/journal.pone.0152785.

Dawson, S. J., & Chivers, M. L. (2018). The effect of static versus dynamic stimuli on visual processing of sexual cues in androphilic women and gynephilic men. *Royal Society Open Science, 5*, 172286. doi:10.1098/rsos.172286

Dawson, S. J., & Chivers, M. L. (2019). The effect of task demands on gender-specificity of attentional biases in androphilic women and gynephilic men. *Personality and Individual Differences, 146*, 120–126. doi:10.1016/j.paid.2019.04.006

Dawson, S. J., Lalumière, M. L., Allen, S. W., Vasey, P. L., & Suschinsky, K. D. (2013). Can habituation of sexual responses be elicited in men and women when attention is maintained? *Canadian Journal of Behavioral Science, 45*, 274–285.

Dawson, S. J., Sawatsky, M. L., & Lalumière, M. L. (2015). Assessment of introital lubrication. *Archives of Sexual Behavior, 44*, 1527–1535. doi:10.1007/s10508-015-0519-z

Dawson, S. J., Suschinsky, K. D., & Lalumière, M. L. (2013). Habituation of sexual responses in men and women: A test of the preparation hypothesis of women's genital responses. *The Journal of Sexual Medicine, 10*, 990–1000. doi:10.1111/jsm.12032

Freund, K., Watson, R., & Rienzo, D. (1989). Heterosexuality, homosexuality, and erotic age preference. *Journal of Sex Research, 26*, 107–117. doi:10.1080/00224498909551494

Geer, J. H., Lapour, K. J., & Jackson, S. R. (1993). The information processing approach to human sexuality. In N. Birbaumer, & A. Ohman (Eds.), *The structure of emotion: Psychophysiological, cognitive, and clinical aspects* (pp. 139–155). Kirkland, WA: Hogrefe & Huber Publishers.

Gerritsen, J., van der Made, F., Bloemers, J., van Ham, D., Kleiverda, G., Everaerd, W., . . . Tuiten, A. (2009). The clitoral photoplethysmograph: A new way of assessing genital arousal in women. *Journal of Sexual Medicine, 6*, 1678–1687. doi:10.1111/j.1743-6109.2009.01228.x

Heiman, J. R. (1980). Female sexual response patterns: Interactions of physiological, affective, and contextual cues. *Archives of Sexual Behavior, 37*, 1311–1316.

Huberman, J. S., & Chivers, M. L. (2015). Examining gender-specificity of sexual response with

concurrent thermography and plethysmography. *Psychophysiology, 52,* 1382–1395. doi:10.1111/psyp.12466

Huberman, J. S., Dawson, S. J., & Chivers, M. L. (2017). Examining the time course of genital and subjective sexual responses in women and men with concurrent plethysmography and thermography. *Biological Psychology, 129,* 359–369. doi:10.1016/j.biopsycho.2017.09.006.

Janssen, E., Everaerd, W., Spiering, M., & Janssen, J. (2000). Automatic processes and the appraisal of sexual stimuli: Toward an information processing model of sexual arousal. *Journal of Sex Research, 37,* 8–23. doi:10.1080/00224490009552016

Kinsey, A. C., Pomeroy, W. B., & Martin, C. E. (1948). *Sexual behavior in the human male*. Philadelphia, PA: W. B. Saunders Company.

Kinsey, A. C., Pomeroy, W. B., Martin, C. E., & Gebhard, P. H. (1953). *Sexual behavior in the human female*. Philadelphia, PA: W. B. Saunders Company.

Laan, E. (1994). *Determinants of sexual arousal in women* (Doctoral dissertation). University of Amsterdam, Amersterdam, The Netherlands.

Laan, E., & Everaerd, W. (1995). Determinants of female sexual arousal: Psychophysiological theory and data. *Annual Review of Sex Research, 6,* 32–76. doi:10.1080/10532528.1995.10559901

Laan, E., Everaerd, W., & Evers, A. (1995). Assessment of female sexual arousal: Response specificity and construct validity. *Psychophysiology, 32,* 476–485. doi:10.1111/j.1469-8986.1995.tb02099.x

Laan, E., & Janssen, E. (2007). How do men and women feel? Determinants of subjective experience of sexual arousal. In E. Janssen (Ed.), *The psychophysiology of sex* (pp. 278–290). Bloomington, IN: Indiana University Press.

Laan, E., Sonderman, M., & Janssen, E. (1996, September). *Straight and lesbian women's sexual responses to straight and lesbian erotica: No sexual orientation effects*. Poster presented at the meeting of the International Academy of Sex Research, Provincetown, MA.

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. *Frontiers in Psychology, 4*, 863. doi:10.3389/fpsyg.2013.00863

Lalumière, M. L., Sawatsky, M. L., Dawson, S. J., & Suschinsky, K. D. (2020). The empirical status of preparation hypothesis: Explicating women's genital responses to sexual stimuli in the laboratory. *Archives of Sexual Behavior.* Advanced online publication. doi:10.1007/s10508-019-01599-5

Lamprecht, V. M., & Grummer-Strawn, L. (1996). Development of new formulas to identify the fertile time of the menstrual cycle. *Contraception, 54*, 339-343.

Levin, R. J. (1980). The physiology of sexual function in women. *Clinics in Obstetrics and Gynaecology, 7*, 213–252.

Levin, R. J. (1992). The mechanisms of human female sexual arousal. *Annual Review of Sex Research, 3*, 1–48. doi:10.1080/10532528.1992.10559874

Levin, R. J. (2003). The ins and outs of vaginal lubrication. *Sexual and Relationship Therapy, 18*, 509–513. doi:10.1080/14681990310001609859

Lykins, A. D., Cantor, J. M., Kuban, M. E., Blak, T., Dickey, R., Klassen, P. E., & Blanchard, R. (2010). Sexual arousal to female children in gynephilic men. *Sexual Abuse: A Journal of Research and Treatment, 22*, 279–289. doi:10.1177/1079063210372141

Masters, W. (1959). The sexual response cycle of the human female: Vaginal lubrication. *Annals New York Academy of Sciences, 83*, 301–317.

Masters, W. H., & Johnson, V. E. (1966). *The human sexual response*. Boston, MA: Little,

Brown & Co.

Meston, C. M., & Gorzalka, B. B. (1996). The effects of immediate, delayed, and residual sympathetic activation on sexual arousal in women. *Behaviour Research and Therapy, 34*, 143-148. doi:10.1016/0005-7967(95)00050-x

O'Brien, F., & Cousineau, D. (2014). Representing error bars in within-subject designs in typical software packages. *Tutorials in Quantitative Methods for Psychology, 10*, 56-67.

Peterson, Z. D., Janssen, E., & Laan, E. (2010). Women's sexual responses to heterosexual and lesbian erotica: The role of stimulus intensity, affective reaction, and sexual history. *Archives of Sexual Behavior, 39*, 880–897. doi:10.1007/s10508-009-9546-y

Polan, M. L., Desmond, J. E., Banner, L. L., Pryor, M. R., McCallum, S. W., Atlas, S. W., . . . Arnow, B. A. (2003). Female sexual arousal: A behavioral analysis. *Fertility and Sterility, 80*, 1480–1487. doi:10.1016/s0015-0282(03)02210-6

Prause, N., & Janssen, E. (2005). Blood flow: Vaginal photoplethysmography. In I. Goldstein, C. M. Meston, S. Davis & A. Traish (Eds.), *Women's sexual function and dysfunction: Study, diagnosis and treatment* (pp. 361–369). London, UK: Taylor & Francis Medical Books.

Pulverman, C. S., Hixon, J. G., & Meston, C. M. (2015). Uncovering category specificity of genital sexual arousal in women: The critical role of analytic technique. *Psychophysiology, 10*, 1396–1408. doi:10.1111/psyp.12467

Rieger, G., Cash, B. M., Merrill, S. M., Jones-Rounds, J., Dharmavaram, S. M., & Savin-Williams, R. C. (2015). Sexual arousal: The correspondence of eyes and genitals. *Biological Psychology, 104*, 56–64. doi:10.1016/j.biopsycho.2014.11.009

Rieger, G., Chivers, M. L., & Bailey, J. M. (2005). Sexual arousal patterns of bisexual men. *Psychological Science, 16*, 579–584. doi:10.1111/j.1467-9280.2005.01578.x

Rosen, R. C., & Beck, J. G. (1988). *Patterns of sexual arousal.* New York, NY: The Guilford Press.

Rosenthal, A. M., Sylva, D., Safron, A., & Bailey, J. A. (2012). The male bisexuality debate revisited: Some bisexual men have bisexual arousal patterns. *Archives of Sexual Behavior, 41*, 135–147. doi:10.1007/s10508-011-9881-7

Sakheim, D. K., Barlow, D. H., Beck, J. G., & Abrahamson, D. J. (1985). A comparison of male heterosexual and male homosexual patterns of sexual arousal. *The Journal of Sex Research, 21*, 183–198. doi:10.1080/00224498509551257

Sawatsky, M. L., Dawson, S. J., & Lalumière, M. L. (2018). Genital lubrication: A cue-specific sexual response? *Biological Psychology, 134*, 103–113. doi:10.1016/j.biopsycho.2018.02.003

Sawatsky, M. L., & Lalumière, M. L. (2020). Effect of a condom cover on vaginal photoplethysmographic responses. *The Journal of Sexual Medicine, 17*, 702–715. doi:10.1016/j.jsxm.2019.12.021

Serretti, A., & Chiesa, A. (2009). Treatment-emergent sexual dysfunction related to antidepressants: A meta-analysis. *Journal of Clinical Psychopharmacology, 29*, 259–266. doi:10.1097/JCP.0b013e3181a5233f

Smithson, M. (2001). Correct confidence intervals for various regression effect sizes and parameters: The importance of noncentral distributions in computing intervals. *Educational And Psychological Measurement, 61*, 605–632. doi:10.1177/00131640121971392

Smithson, M. (n.d.). *Scripts and software for noncentral confidence interval and power calculations*. Retrieved from http://www.michaelsmithson.online/stats/CIstuff/CI.html

Spape, J., Timmers, A. D., Yoon, S., Ponseti, J., & Chivers, M. L. (2014). Gender-specific

genital and subjective sexual arousal to prepotent sexual features in heterosexual women and men. *Biological Psychology, 102*, 1–9. doi:10.1016/j.biopsycho.2014.07.008

Suschinsky, K. D. (2012). *An exploration of genital arousal category-specificity and sexual concordance in men and women* (Doctoral dissertation). University of Lethbridge, Lethbridge, AB, Canada.

Suschinsky, K. D., Dawson, S. J., & Chivers, M. L. (2020). Assessing gender-specificity of clitoral responses. *The Canadian Journal of Human Sexuality*. Advanced online publication. doi:10.3138/cjhs.2019-0061

Suschinsky, K. D., & Lalumière, M. L. (2011a). Prepared for anything?: An investigation of female genital arousal in response to rape cues. *Psychological Science, 22,* 159–165. doi:10.1177/0956797610394660

Suschinsky, K. D., & Lalumière, M. L. (2011b). Category-specificity and sexual concordance: The stability of sex differences in sexual arousal patterns. *The Canadian Journal of Human Sexuality, 20*, 93–108.

Suschinsky, K. D., Lalumière, M. L., & Chivers, M. L. (2009). Sex differences in patterns of genital sexual arousal: Measurement artifacts or true phenomena? *Archives of Sexual Behavior, 38*, 559–573. doi:10.1007/s10508-008-9339-8

Tabachnick, B. G., & Fidell, L. S. (2007). Experimental design using ANOVA. Belmont, CA: Thomson Brooks/Cole.

Timmers, A. (2019). *Attractiveness and sexual response* (Doctoral dissertation). Queen's University, Kingston, ON, Canada.

van Anders, S. M. (2015). Beyond sexual orientation: Integrating gender/sex and diverse sexualities via sexual configurations theory. *Archives of Sexual Behavior, 44*, 1177–1213. doi:10.1007/s10508-015-0490-8

Waxman, S. E., & Pukall, C. F. (2009). Laser Doppler imaging of genital blood flow: A direct measure of female sexual arousal. *The Journal of Sexual Medicine, 6*, 2278–2285. doi:10.1111/j.1743-6109.2009.01326.x

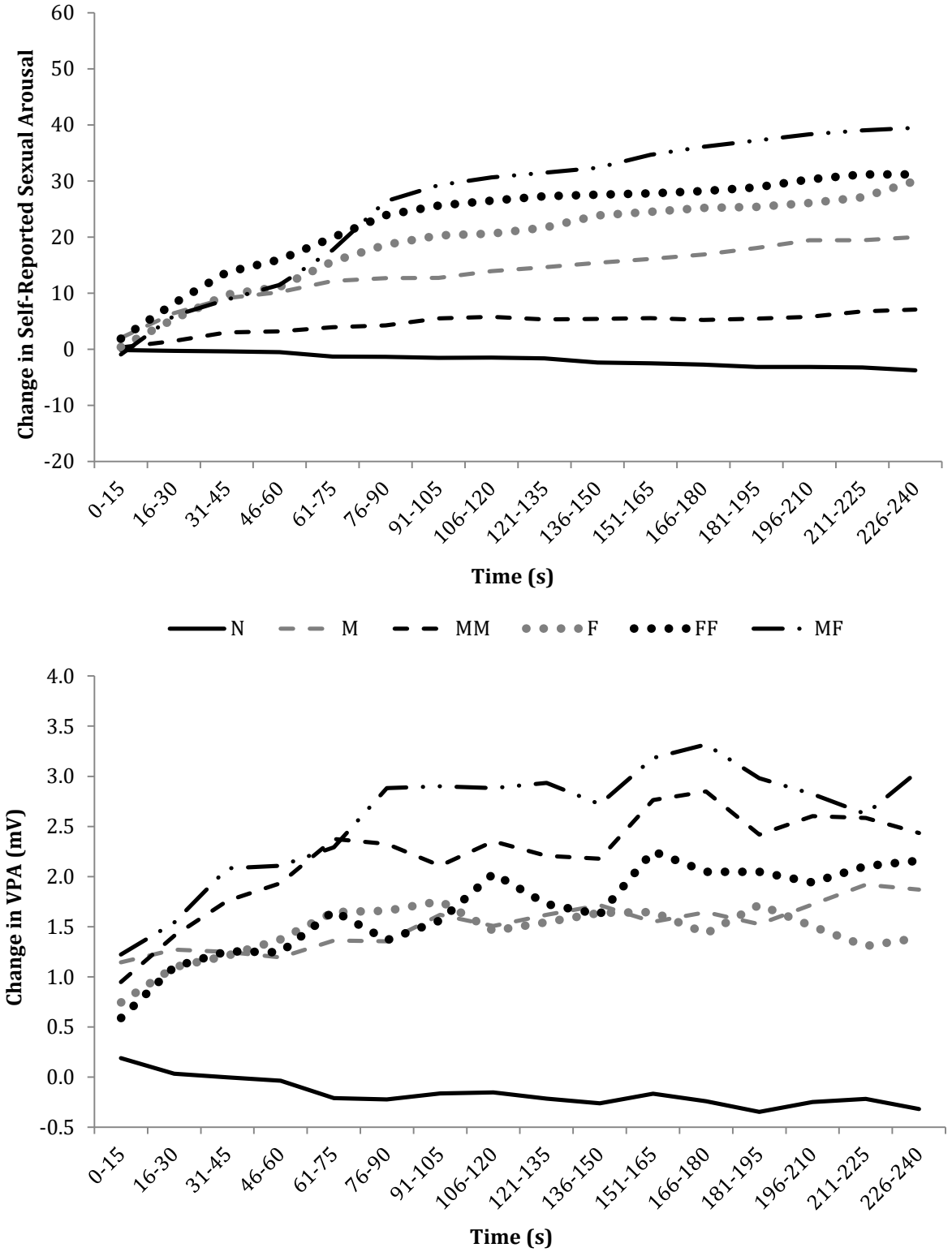

Figure 3.1. Time course of the change in women's continuous self-reported sexual arousal (top) and vaginal pulse amplitude (bottom) across stimulus duration. N = nonsexual; M = male solitary masturbation; MM = male–male partnered sex; F= female solitary masturbation; FF = female–female partnered sex; MF = male–female partnered sex

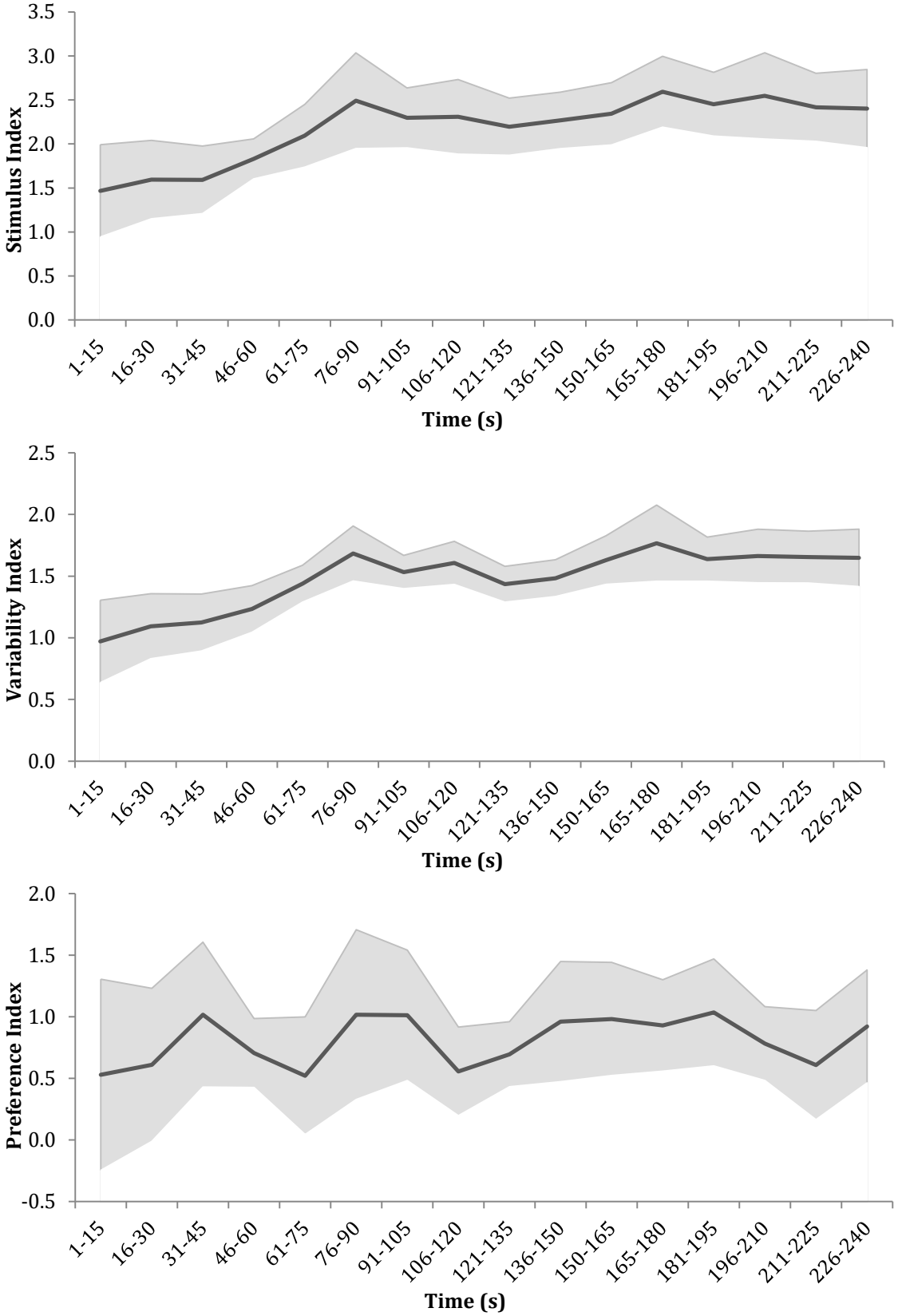

Figure 3.2. Time course of the stimulus index (top), preference index (middle), and variability index (bottom) for vaginal pulse amplitude. Shaded area represents the 95% CI.

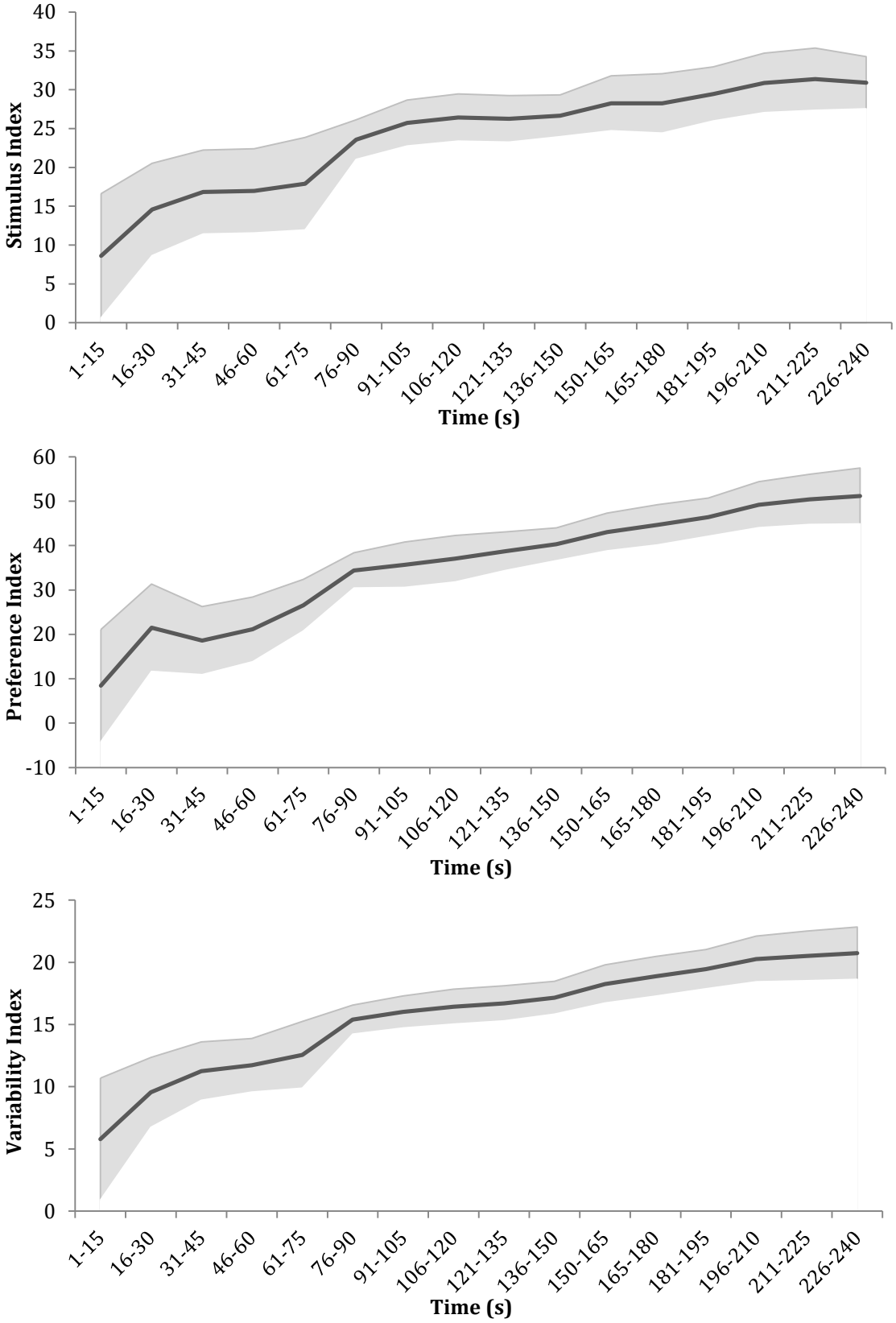

Figure 3.3. Time course of the stimulus index (top), preference index (middle), and the variability index (bottom) for women's continuous self-reported sexual arousal. Shaded area represents the 95% CI.

Appendix

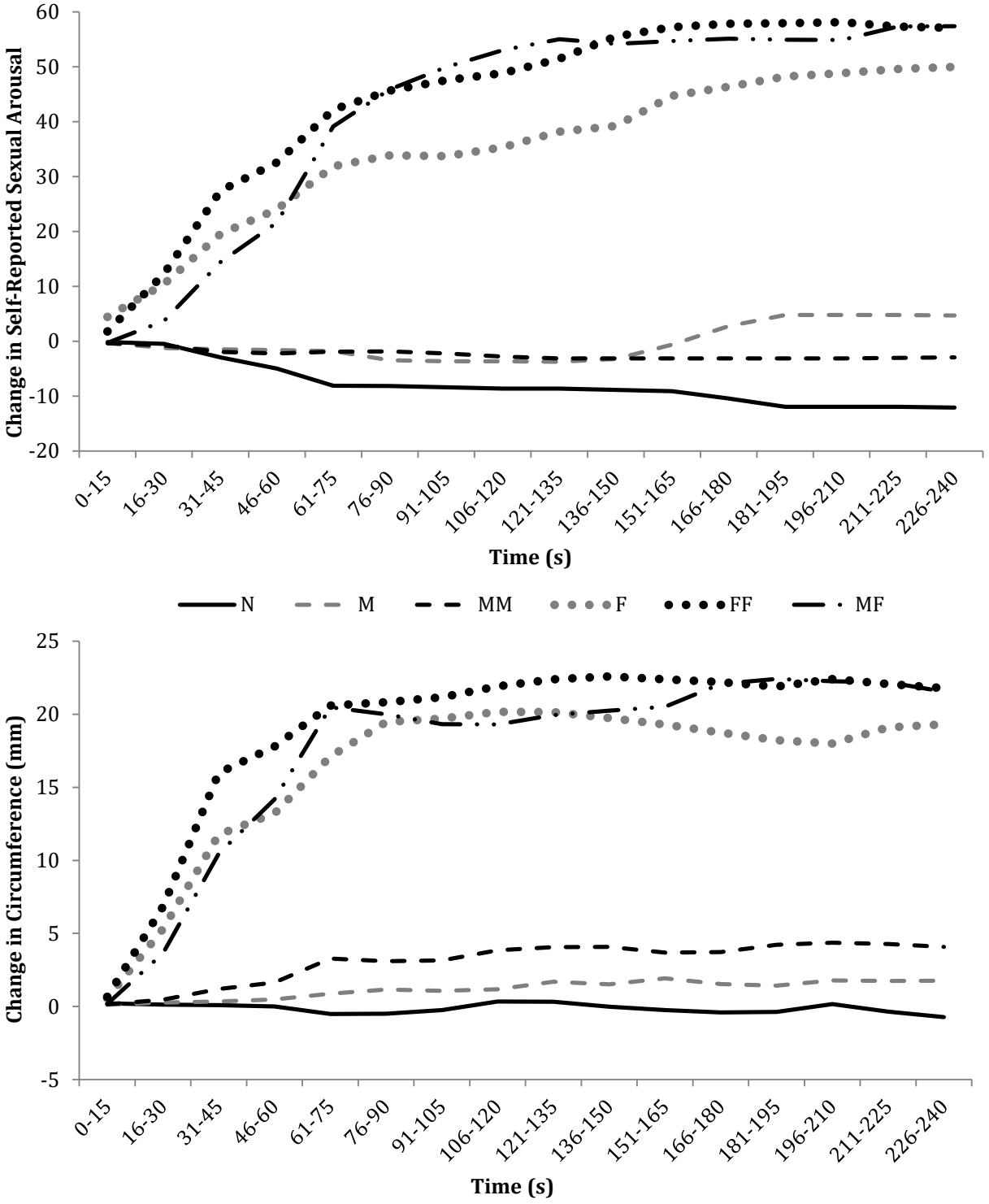

Figure 3.A1. Time course of change in men's continuous self-reported sexual arousal (top) and penile circumference (bottom) across stimulus duration. N = nonsexual; M = male solitary masturbation; MM = male–male partnered sex; F= female solitary masturbation; FF = female–female partnered sex; MF = male–female partnered sex

CHAPTER 4

Effect of a Condom Cover on Vaginal Photoplethysmographic Responses

Abstract

Introduction: The vaginal photoplethysmograph (VPP) is a reusable intravaginal device often employed in sexual psychophysiology studies to assess changes in vaginal blood flow, an indicator of sexual arousal.

Aim: To test whether placing a disposable cover on the VPP probe impacts the acquired data. A condom cover would reduce risk of disease transmission and likely increase participant comfort, but may negatively impact the VPP signal.

Method: The genital responses of 25 cisgender women (mean age = 21.3 years, standard deviation = 2.6) were assessed with VPP in a within-subjects design with two conditions—with and without a polyisoprene condom cover. Sexual responses were elicited by audiovisual film clips that varied in erotic intensity: nonsexual (nonsexual male–female interaction), low-intensity sexual (nude exercise), high-intensity sexual (male–female intercourse). Women continuously rated their sexual arousal during stimulus presentations.

Main Outcome Measure: Change in vaginal pulse amplitude (VPA) and also self-reported sexual arousal.

Results: The magnitude of sexual response to each stimulus category and the overall pattern of results were found to be highly similar in the cover-off and cover-on conditions. The high-intensity sexual stimulus category elicited a greater sexual response compared to all other categories. The low-intensity sexual category elicited a (small) genital response in only the cover-on condition, although we suspect this is a spurious finding. There was no difference in the average number of edited movement artifacts across conditions.

Clinical Implications: Potential benefits of encasing the VPP probe with a protective cover include enhanced participant safety and comfort, especially if assessing genital responses of high-risk or immunocompromised samples. Use of a cover complies with current guidelines for

reprocessing semi-critical medical devices (eg, vaginal ultrasound probes) in many regions.

Strengths & Limitations: Although the idea of a VPP probe cover had been discussed among sexual psychophysiology researchers, this is the first study to empirically test whether a cover could jeopardize VPP data. Potential limitations include the use of a 10 Hz VPP sampling rate and a cover that was not tailored to the size of the VPP probe.

Conclusion: Placing a protective cover on the VPP probe did not appear to meaningfully impact sexual arousal or the VPP data. Based on these results and the potential advantages of a protective cover, researchers may wish to integrate the use of a condom cover in their experiment protocols and clinical applications.

Psychophysiological methods are used to study the physiological, cognitive, and affective determinants of sexual arousal and their interactions.[1] One of the principal physiological changes indicating sexual arousal is an increase in genital vascular blood flow (ie, genital vasocongestion).[2,3] Changes in genital vasocongestion are commonly assessed in psychophysiological studies for a broad range of topics, including: sexual orientation, preferences, and interests[4]; sex and gender differences in sexual arousal[5,6]; determinants of sexual arousal[7]; comparison with other measures of sexual arousal[8-10]; menstrual cycle, contraceptive use, and hormones[11,12]; sexual offending and paraphilias[13]; and sexual dysfunctions.[14,15] The most widely used method to assess genital vasocongestion in women is the vaginal photoplethysmograph (VPP).

The use of photoplethysmography to assess vaginal responding was first documented by 2 independent groups of researchers—Geer et al[16,17] and Palti and Bercovici[18]—and the device was subsequently improved by Hoon et al.[19] The modern VPP probe is a clear acrylic cylindrical probe the size of a tampon that contains a light-emitting diode and a photo-sensitive light detector that is inserted intravaginally. Light emitted from the light source diffuses through the tissues of the vaginal wall and the circulating blood. When vaginal tissues engorge with blood, they become less transparent, which is thought to result in more indirect light reflected back from the tissues to the probe. An increase in backscattered light is interpreted as an increase in vasocongestion. Although the exact physiologic process underlying the observed changes in the VPP signal remains elusive,[20] several studies have supported the validity of VPP as a measure of sexual response, with data suggesting that the alternating current (AC)—referred to as vaginal pulse amplitude (VPA)—is superior in its specificity compared to the direct current (DC) signal.[16,20-23]

VPP is not without its limitations and authors have identified and evaluated its strengths

and weaknesses.[20,24-27] The field continues to work toward greater standardization and systematization of VPP methodology (eg, sampling rates, data reduction, data artifact removal), which benefits replication attempts and interpretation across studies.[28] Other areas of inquiry include clarifying which underlying physiological processes the signals actually measures[29] and addressing questions about the characteristics of willing participants and result generalizability.[30,31] Ethical and participant concerns have also been considered. Among the potential issues is how to properly clean the reusable VPP device in order to prevent cross-infection and disease transmission.

The VPP was initially sanitized using Zephiran Chloride,[16,17] but this solution was found to be ineffective in destroying viruses such as herpes.[32] Since this time, VPP decontamination has typically been accomplished through high-level disinfection procedures involving such solutions as Cidex OPA and Cidex Plus that contain ortho-phthalaldehyde and glutaraldehyde, respectively (Advanced Sterilization Products, Irvine, CA, USA).[20,22,32,33] These high-level disinfection procedures are commonly used in hospitals to clean medical devices and align with the recommendations from North American disease control centres that reusable devices and those that contact mucous membranes (ie, semi-critical medical devices) be, at a minimum, subjected to high-level disinfection after each use.[34,35] However, recent research has shown that aldehyde-based high-level disinfectants, such as Cidex OPA and Cidex Plus, are not virucidal against human papillomavirus (HPV).[36,37,38] HPV is estimated to be the most common sexually transmitted infection and its carcinogenic effects are well-documented.[39,40] It has been demonstrated that endocavitary (eg, vaginal, anal, oral) ultrasound probes can remain contaminated with HPV after undergoing approved disinfectant reprocessing procedures.[36,37] There is also evidence of aldehyde-resistant mycobacteria strains and these strains have been linked to patient cross-infection.[41]

To mitigate the risk of HPV transmission, it has been recommended that VPP probes undergo a prewash with sodium lauryl sulphate (sodium dodecyl sulfate) prior to Cidex disinfection.[33] There are some early reports that sodium lauryl sulphate can inactivate sexually transmitted infections (STIs), including HPV[42,43]; however, Meyers et al[37] pointed out that rigorous research on HPV disinfection has been limited by the traditional difficulty in producing suitable HPV titers in laboratory settings. Until there is up-to-date research on the effectiveness of sodium lauryl sulphate to inactivate HPV (and other infections, diseases, and viruses), additional infection-control measures for VPP ought to be considered.

Disinfection requirements for endocavitary ultrasound probes can serve as an important reference for updating VPP decontamination protocols given that both are semi-critical devices that can be used intra-vaginally. Recent disinfection guidelines for vaginal ultrasound probes in Australia,[44] Canada,[45] and United States of America[35] specify the use of a single-use barrier in addition to high-level disinfection. For example, reprocessing requirements from the College of Physicians and Surgeons of British Columbia[46] state that following high-level disinfection, all semi-critical internal ultrasound probes must be covered with a single-use barrier, such as a probe cover, sheath, or condom, prior to patient use to prevent contamination.

Placing a single-use, disposable cover on the VPP device would prevent it from coming into direct contact with the genitals and would serve to further protect participants from cross-infection.[47] In addition to being an ethical imperative, stringent protection procedures could enhance participant comfort and willingness to participate. In a recent study by Huberman et al[48] that assessed volunteer bias and factors affecting individuals' level of comfort with the idea of participating in sexual psychophysiological research, 7% of individuals who reported being unwilling to participate in a VPP study cited safety concerns (eg, device sanitation) as a factor affecting their decision. Genital contact with the VPP was a concern reported by 26% of

unwilling individuals. Although it is unknown to what extent a barrier between the genitals and the VPP probe would assuage safety concerns of prospective participants and promote participation among those typically unwilling to volunteer for such studies, increasing the diversity of participants could enhance result generalizability. This is particularly important for sex research, which is thought to be especially susceptible to volunteer bias.[49,50,51]

No research studies have encased the VPP probe with a protective cover, although the possibility of doing so has been discussed by Carrito et al[47] and in personal communications with researchers in the field (eg, on the email listserve *Sexlab*). One concern is that a cover could alter the VPP signal, potentially by influencing light diffusion or scatter; altering the temperature of the light source or detector[23]; or reducing the amount of emitted and reflected light via light absorption from the cover material. Disruption of the VPP signal could result in problematic data, such as an increased number of artifacts, unreliable signal, disrupted signal morphology, or weaker data output. The impact of a cover has never been empirically examined.

The aim of the current exploratory study was to test the effect of placing a polyisoprene condom over the VPP probe. To do so, we used a within-subjects design where women's genital responses were assessed in both a cover-off and cover-on condition. In both conditions, probe insertion was facilitated by a silicone-based lubricant. Audiovisual stimuli of varying erotic intensities were presented to test for potential effects of the cover on VPP sensitivity.

MATERIAL AND METHOD

Participants

Participants were recruited via advertisements posted at a Canadian university that requested participants for a "sexual arousal study." 80 women contacted the laboratory by email or phone and were provided information about the study's purpose and procedures. Of these, 50 women expressed interest and were screened for eligibility. Eligible participants were cisgender

women age 18 and older who had experienced vaginal penetration and were familiar with erotic material. Women were ineligible if they were taking medications that could affect their sexual functioning; had a history of sexual dysfunction; currently had a sexually transmitted infection (STI); or were pregnant or trying to conceive. Prospective participants were informed that samples of the plethysmograph cover and silicone-based lubricant were available if they were concerned about potential skin irritation; no one requested samples. 33 women reported eligibility and scheduled a laboratory session. Of these, 30 attended their scheduled session and participated in the study (questionnaire responses confirmed eligibility). Data collection ceased once the target sample size of 30 was reached. A sample size of 30 was selected based on a previous study in which we compared the VPP responses of 20 women and detected within-group differences between sexual and non-sexual stimuli at Hedge's $g = 0.66$, (95% CI: 0.34 to 1.05)[52]; in the current study, we wanted to be able to detect smaller differences and obtain narrower confidence intervals. A sample size of 30 took into account the possibility of data loss due to problematic VPP signals, uncorrectable movement artifacts in the VPP data, or software malfunctions that affect data collection (up to nearly 30% in some studies[15]).

The final sample consisted of 25 cisgender women (mean age = 21.3 years, standard deviation [SD] = 2.6, range = 18–27). Most participants had attended or completed post-secondary education ($n = 20$) and most had casual, part-time, or full-time employment ($n = 16$). Based on responses to a questionnaire item adapted from the Kinsey scale,[53] 20 were androphilic (ie, exclusively or mostly sexually attracted to men) and 5 were androgynephilic (ie, sexually attracted to both men and women). Women were considered androphilic if they provided ratings of 0 ($n = 11$) or 1 ($n = 9$) for the Kinsey item, and androgynephilic if they provided ratings of 2 ($n = 2$), 3 ($n = 1$), or 4 ($n = 2$). Participants self-identified as heterosexual ($n = 13$), mostly heterosexual ($n = 10$), bisexual ($n = 1$), or pansexual ($n = 1$). Most women were in a committed

(*n* = 11) or dating (*n* = 4) relationship, and had a sexual partner (*n* = 20; 19 had male partners and 1 had both male and female partners) at the time of testing. 21 women were taking hormonal contraceptives.

Experimental Stimuli

Experimental stimuli comprised 12, 60-s audiovisual film clips from 3 stimulus categories: nonsexual interaction (male–female partnered tango, ballet, or acro-yoga), low-intensity sexual (a woman nude exercising), and high-intensity sexual (male–female sexual intercourse). Women were presented with 2 exemplars from each stimulus category per condition (ie, cover-on, cover-off). 2, 60-s neutral, male-narrated film clips (nature documentaries) were used to determine women's baseline VPA for each condition. In addition, a 120-s neutral still image (beach scene) was used as an adaptation stimulus at the beginning of each condition.

The nonsexual interaction film clips depicted different male–female couples engaging in nonsexual activities, such as partnered ballet, tango, or acro-yoga. Women were clothed; men were clothed in 2 films and were bare-chested in 2 films. The purpose of including nonsexual male–female interactions was to present stimuli that were more comparable to the high-intensity intercourse stimuli with the exception of overt sexual cues (eg, depictions of physical touch, with a focus on body movement). These nonsexual interaction film clips were selected from open-access websites and had not been used in prior research studies.

The low-intensity sexual films depicted a nude woman engaging in low-impact physical exercise or stretching. 2 film clips were from Chivers et al[5] and 2 were from Fairweather et al[54]; the latter were abbreviated from 120 s to 60 s. Female nude exercise was selected as an appropriate low-intensity sexual stimulus category because it elicits higher self-reported sexual arousal and genital responses relative to neutral (nonsexual) stimuli, whereas the response

discrimination between male exercise and neutral categories is less distinct.[5] More explicit sexual film clips were not used as low-intensity stimuli in light of recent research showing that in some samples, films depicting manual stimulation or masturbation elicit comparable responses to depictions of sexual intercourse.[52,55]

The high-intensity sexual stimuli were 60-s excerpts from the 4, 300-s sexual films clips used in Dawson et al.[8] The Dawson et al clips were originally sourced from female-oriented commercially available films. The 4, 60-s excerpts used in the current study depicted different male–female couples engaging in penetrative intercourse and did not include orgasm.

The 2 neutral condition baseline film clips were from nature documentaries in which there was no reference to sex or reproduction. Previous studies confirmed that these neutral stimuli do not elicit physiological or self-reported sexual responses.[8,52] All experimental stimuli were presented with the original background music and sound with the exception of the Fairweather et al[54] clips to which music was added.

At the onset of each condition, participants were presented with the adaptation stimulus followed by the neutral condition baseline stimulus and 6 of the 12 experimental stimuli (two exemplars were presented for each stimulus category); the other 6 were presented in the next condition. Exemplars were paired, such that the same 2 exemplars were always presented in the same condition. To illustrate, one low-intensity stimulus from Chivers et al[5] and one from Fairweather et al[54] were paired; as such, each condition contained one exemplar from each of these stimulus sets. Also, each pair of nonsexual interaction films contained one exemplar with a bare-chested man and one exemplar with a fully clothed man. Pairing, therefore, allowed control over stimulus content in each condition.

The exemplar pair and the presentation order were randomized using a random sequence generator, with the provision that 2 exemplars of the same stimulus category could not be

presented successively. Exemplar pairs were counterbalanced across participants. Stimuli and self-report questions were presented via PrefTest software (Limestone Technologies Inc., Odessa, ON) and displayed on a 52 cm computer monitor situated at eye-level approximately 150 cm from the participant. The audio components were presented through noise-cancelling headphones.

Genital Responses

Genital response data were sampled continuously throughout each film clip using Limestone Technologies Inc. (Odessa, ON, Canada) DataPac_USB system and PrefTest software, Version 10, and were recorded at a rate of 10 samples/s and band-pass filtered (0.5–10 Hz). Genital responses were assessed using a VPP probe from Technische Handelsonderneming Coos (Purmerend, The Netherlands). The VPP probe was approximately 1.5 cm in diameter and 4.5 cm in length and contained an orange-red spectrum light-emitting diode and a photodiode light detector situated at a distance of approximately 0.5 cm from the light source. Changes in vaginal pulse amplitude (VPA) were measured in millivolts (mV). The probe was inserted intravaginally so that the photodiode was at a depth of 5 cm from the introitus. A silicone anchor (5 cm long and 1–2 cm in width) was attached to the cable of the VPP to ensure that the light source and detector remained inserted to a correct and consistent depth and orientation throughout the session and across participants. For each participant, the same VPP device was used in the cover-off and cover-on conditions. Between conditions, an experimenter cleaned the device using antibacterial soap containing sodium lauryl sulphate to remove any remaining personal lubricant. After each testing session, the VPP underwent a prewash with the sodium lauryl sulphate soap and was subjected to a high-level disinfection protocol involving Cidex® OPA (ortho-phthalaldehyde).[20] A total of four different probes were used in this study.

Condom Cover

Before the cover-on condition, the experimenter placed a latex-free SKYN® Original condom (Lifestyles Healthcare, Iselin, NJ, USA) on the VPP using nitrile gloves. SKYN® condoms are made from polyisoprene—synthetic latex—and are suitable for people with natural latex allergies. As shown in Figure 4.1, the condom covered the probe, the silicone anchor, and several inches of the cable. Two small plastic medical-grade elastic bands were used to affix the condom to the cable (placed above and below the silicone anchor). The condoms were 5.3 cm wide and 19.0 cm long (https://www.skyn.com/en-us/condoms/). Using the elastic bands, we attempted to move any excess condom material and resulting folds and ripples away from the light source and detector.

During pilot testing, other types of covers and protective membranes were considered and some were tested, but potential problems were identified. For instance, some disposable sheaths (eg, ultrasound sheaths) were not elastic and could not stretch over the silicone anchor, and they were much larger than the probe; a concern was that excess material could affect VPP light diffusion. Also, condoms are less expensive and less susceptible to perforation than ultrasound sheaths.[55] We concluded that the condom cover was superior when considering the following factors: size, translucence, durability, malleability, elasticity, cost efficiency, and its intended use involving genital contact. SKYN® condoms were selected because they are latex-free, thin, highly translucent, resistant to perforation, and there was less excess material compared to other covers that were considered. The authors have no relationship with the manufacturer. MyONE® size E55 condoms (ONE, Boston, MA, USA)—one of the smallest commercially available condoms—were also considered for their relatively small width (4.5 cm) and length (12.5 cm), but were not selected because they are latex (https://www.onecondoms.com/pages/myone). Non-latex polyurethane condoms were not selected because the material does not stretch as readily as polyisoprene or latex and is more prone to breakage.

Personal Lubricant

In both the cover-off and cover-on conditions, the participant was provided a package of silicone-based Wet Platinum Premium Lubricant® (Trigg Laboratories, Valencia, CA, USA; http://stayswetlonger.com/products/wet-platinum-premium-lubricant/#overview) to facilitate VPP insertion (oil-based lubricants cannot be used with polyisoprene condoms). Also, the condoms were pre-lubricated; use of personal lubricant in both conditions allowed for greater consistency across conditions. Participants were instructed to apply a dime-sized dollop of personal lubricant on the probe (or the condom in the cover-on condition). According to the website, Wet Platinum® is paraben-free and has been accepted by the US Food and Drug Administration (FDA) as a ClassII 510(k) Medical Device. Silicone lubricants are long lasting (less prone to absorption) and are safe to use with all types of condoms. Tachedjian et al[56] found Wet Platinum to be one of the two safest lubricants of the 14 types tested and noted that it was non-toxic toward epithelial cell lines, and ectocervical and colorectal tissues (ie, vaginal and rectal issues). Wet Platinum has been used in other sex research studies.[57]

Self-Reported Sexual Arousal

Women reported their sexual arousal before and after each stimulus presentation, and continuously during the stimulus. Before and after each stimulus, participants rated their overall sexual arousal ("*How aroused did you feel during the film*?") and their perceived genital response ("*How aroused did your genitals feel during the film*?") using a 9-point Likert scale, where 1 was the lowest level of response (ie, no arousal) and 9 was the highest level of response (ie, similar to the arousal experienced before orgasm). Women provided their pre- and post-stimulus ratings by pressing a numeric value on the keypad. During each stimulus presentation, women were instructed to press the plus ("+") and minus ("-") keys on the same keypad

whenever they felt an increase or decrease, respectively, in sexual arousal. Pressing the plus and minus keys corresponded to the increase and decrease of a green bar on the side of the computer screen, which ranged from 0 (no sexual arousal) to 100 (maximum degree of sexual arousal, similar to that experienced before orgasm).

Questionnaires

Women were asked to complete a standard questionnaire package that included biographical, sexual history, and sexual interest questionnaires. The questionnaire was accessed via a secure website and was completed using a tablet. At the conclusion of the experiment, women were asked to complete a study feedback questionnaire. Questions inquired about comfort, ease of use of the device and associated procedures, and the quality of sexual stimuli. Questions were in both multiple choice and short-answer formats.

Procedure

Eligible women were asked to schedule a laboratory session when they were not menstruating. Women were instructed to refrain from: sexual activity 24 hours prior to testing; physical exercise 1 hour prior to testing[58]; and alcohol, tobacco, cold medication, and recreational drug use on the day of testing. Questionnaire responses confirmed that all participants complied with these instructions.

Women were tested individually by a female experimenter. At the onset of the session, women received a detailed verbal overview of the entire experimental procedure and were instructed on how to properly place the VPP probe using the personal lubricant. Women were asked to “respond as naturally as possible” to the films and to avoid any movements (eg, muscles contractions, genital touching, coughing, or talking) during the films. After providing written consent, women were left in a private room where they undressed from the waist down and sat comfortably in the reclining chair situated in front of the monitor. Participants were instructed to

wear nitrile gloves and to squeeze a dime-sized amount of personal lubricant on the tip of the probe (or on the condom in the cover-on condition) prior to insertion. Once the device was inserted, women were asked to remove the gloves and dispose of them in a garbage can adjacent to the chair, and to inform the experimenter that they were ready to begin the session. Women communicated with the experimenter using a hands-free intercom system.

The 120-s adaptation stimulus was presented first for the purpose of allowing the participants to become accustomed to the experimental setting and to the VPP, and to allow genital response readings to stabilize. Women had an opportunity to voice any questions or concerns before continuing with the session (none of the participants indicated that they had questions or concerns). Next, the 60-s neutral condition baseline stimulus was presented to establish women's baseline level of responding, followed by six 60-s experimental stimuli (two stimuli from each stimulus category). The order of the conditions was counterbalanced across participants: Of the final sample, the genital responses of 12 women were first assessed in the cover-on condition followed by the cover-off condition; the order was reversed for the other 13 women. After all stimulus presentations in the first condition, women were asked to redress and complete the questionnaire package (approximately 20 min in length). Before continuing with the other experimental condition, women were provided with a brief reminder of the experimental procedure. The experimental procedure was identical for each condition.

Each stimulus presentation was separated by an interstimulus interval (ISI) that ranged from 30 s to 180 s. Immediately after each stimulus, participants were asked to use the keypad to rate their overall sexual arousal and perceived genital response, and to relax until further instruction. Once VPA returned to approximate baseline levels of responding (a minimum of 30 s), women were asked to rate their pre-stimulus sexual arousal and perceived genital response, and to move the green bar to their current level of sexual arousal. Women were then presented

with the following message on the monitor: “Please be still. The next film will begin shortly.” The message was presented for 5 s during which time their trial baseline genital response was recorded. Afterwards, the next film began.

If after 120 s, women’s VPA did not return to the level of response established during the condition baseline stimulus, a distraction task was initiated (eg, counting backwards aloud from 100 in different multiples).[6] The distraction task instructions were presented on the computer monitor. Once VPA returned to baseline or after a maximum of 60 s (ie, 180 s of the ISI), the pre-stimulus sexual arousal questions were presented on the computer monitor, indicating to the participant to cease counting.

At the end of the experiment (ie, once both experimental conditions and the questionnaire package were completed), women were asked to complete the study feedback questionnaire, were debriefed about the purpose of the study, were given an opportunity to provide verbal feedback, and were provided $40 CDN compensation. The entire session was approximately two hours in length. The University of Ottawa Research Ethics and Integrity Board reviewed and approved all experimental procedures in accordance with the ethical guidelines of the Canadian Tri-Council Policy Statement.

DATA ANALYSIS

Data Preparation

An experimenter and researcher assistant who were blind to experimental conditions reviewed the VPP data to visually inspect the waveforms and to detect and remove movement artifacts (sudden, drastic changes in the VPA waveforms). There was high agreement between both reviewers and any discrepancies were discussed. Data from 5 of the 30 participants were excluded from the analyses for the following reasons: technical difficulties that resulted in VPP data not being recorded in the cover-on condition (n = 1); no observed increase in VPA for any

experimental trials relative to the condition baseline in the cover-on condition (n = 1; her responses were minimal, <1 mV, in the cover-off condition); a substantial number of movement artifacts (> 20 s of missing data per trial) in both exemplars of the high-intensity stimulus category in the cover-on condition, which prevented the calculation of mean VPA for that category (n = 1; all trials were marked by a number of movement artifacts for a total of 26 s and 85 s removed in the cover-off and cover-on condition, respectively); or a problematic VPP signal (ie, uncorrectable, repetitive artifacts in the data, unusual waveform morphology) across all trials in the cover-off (n = 1) or cover-on (n = 1) conditions. Figure 4.2 presents examples of the VPP waveforms from 4 participants at the onset (0–25 s) of a high-intensity sexual stimulus in the cover-off and cover-on conditions: 2 sets of examples were randomly selected from the participants with valid data, and 2 are participants whose data were excluded due to problematic signal morphology.

If only one exemplar had a substantial number of movement artifacts (> 20 s of missing data), the affected trial was excluded from the analyses; the VPA for the affected stimulus category was based on the valid exemplar for that category (n = 2, 1 trial each in the cover-on condition). If a movement artifact was recorded during a trial baseline (n = 2, one trial in the cover-off condition, one in the cover-on condition), the baseline for the affected exemplar was replaced by the average VPA of the valid trial baselines in that condition. For one woman, VPA did not return to baseline for the last three trials in the cover-on condition; VPA for these stimulus categories was based on the unaffected exemplar. Among the final sample of participants (n = 25), there was no difference in the average number of edited movement artifacts (removed in 1 s intervals) for the cover-off (mean = 3.7 s, SD = 5.9, median = 1.0 s) and cover-on (mean = 3.6 s, SD = 8.7, median = 0 s) conditions across the seven stimulus presentations, g = 0.02, (95% CI: –0.58 to 0.62).

To examine change in genital response, the trial baseline was subtracted from the mean VPA for each 60-s stimulus (mean-minus-baseline). The trial baselines were stable within each condition. The mean-minus-baseline values of the exemplars in each condition were averaged to produce a mean score for each stimulus category. Change in VPA from baseline is commonly presented in psychophysiology studies.[5,6]

Similarly for continuous self-reported sexual arousal, the trial baseline was subtracted from the mean response for each stimulus. The change scores for the 2 exemplars in each condition were averaged to produce one mean score for each stimulus category. We also averaged pre/post-stimulus change scores for self-reported sexual arousal and perceived genital response for each stimulus category. The 3 self-report measures produced a similar pattern of results; as such, we present only mean change in continuous self-reported sexual arousal. This is consistent with the recommendation to use continuous self-report measures (and change scores) because they are less affected by potential impression management biases.[59]

Analysis

For analyses of main effects, which involved one or more factors with multiple levels, we conducted within-subjects analyses of variance (ANOVAs) with either VPA or self-reported sexual arousal (separate analyses) as the dependent variable (DV). Outliers were defined as values greater than 2.58 standard deviations from the mean. 6 outliers were identified in the VPA data across all stimulus presentations in both conditions (5 in the cover-off and 1 in the cover-on condition), and there was no more than one outlier per stimulus. Inclusion of outliers did not affect the pattern of results and, therefore, outliers were retained. Some degree of skewness and kurtosis was observed, which was expected given the relatively small sample. No data transformations were applied in order to maintain the original scale for VPA. When the assumption of sphericity was violated, a Greenhouse-Geisser correction was applied. We present

the *F*-statistic and the partial eta-squared (η_p^2) effect size with a 90% CI. The η_p^2 CI was calculated using the Smithson script.[60,61] The 90% CI is appropriate for one-sided statistics that do not have negative values, such as η_p^2.[62]

For pairwise comparisons with either VPA or self-reported sexual arousal as the DV, we calculated Hedge's *g* according to the method outlined by Borenstein et al[63] and presented in Sawatsky et al.[52] Hedge's *g* represents the effect size of the difference between the 2 within-subjects variables being compared (eg, change in VPA elicited by the high-intensity sexual film in the cover-on versus cover-off conditions). Hedge's *g* is a corrected form of Cohen's *d* that can be interpreted the same as *d*, but is considered more appropriate for relatively small samples.[63] Hedge's *g* effect sizes are presented with 95% CI, which were calculated based on the standard error of *g* and using *t* values. The 95% CI is more appropriate for *g* than 90% CI because values can be both positive and negative. The error bars on Figure 4.3 represent the 95% CIs and were calculated using the method outlined by O'Brien and Cousineau.[64]

The within-subjects correlation between responses (mean-minus-baseline VPA or self-reported sexual arousal) in the cover-off and cover-on conditions is also presented. We computed the Pearson correlation coefficient (*r*) for each participant (within-subjects) and applied a Fisher's *z* transformation. Correlations were based on 7 pairs of data, one pair for each stimulus presentation. The 95% CIs were calculated around the mean of the *z*-transformed coefficients. The mean coefficients and the 95% CIs were then transformed back to *r*.

RESULTS

Film Manipulations

Self-reported sexual arousal was examined to determine whether the stimuli elicited the intended emotional response. One woman reported that during the first 2 experimental trials she forgot to move the green bar to indicate changes in continuous self-reported sexual arousal. Self-

reported sexual arousal for the 2 affected stimulus categories was based on the valid trials for that category. One woman reported that for an entire condition, she misunderstood the instructions and did not move the green bar during the films; her data are excluded from the self-report analyses.

The top portion of Figure 4.3 shows the average change in continuous self-reported sexual arousal for each stimulus category in the cover-off and cover-on conditions (the mean and SD are reported for each stimulus category in the Figure). A 2 (condition: cover-off, cover-on) × 4 (stimulus category: neutral baseline, nonsexual interaction, low-intensity sexual, high-intensity sexual) within-subjects ANOVA was conducted with continuous self-reported sexual arousal as the DV. There was a main effect of stimulus category, $F(1.48, 34.08) = 34.40$, $\eta_p^2 = .60$ (90% CI: 0.42 to 0.71), Greenhouse-Geisser $\varepsilon = .49$. There was no main effect of condition, $F(1, 23) = 0.36$, $\eta_p^2 = .02$ (CI: 0.00, 0.16), and no interaction between condition and stimulus category, $F(2.08, 47.72) = 0.47$, $\eta_p^2 = .02$ (CI: 0.00, 0.09), Greenhouse-Geisser $\varepsilon = .69$.

The high-intensity sexual stimulus category elicited much stronger self-reported sexual arousal than any other category. The high intensity sexual stimulus was rated as more sexually arousing than the low-intensity stimulus in the cover-off condition, $g = 1.39$ (95% CI: 0.62 to 2.25) and the cover-on condition, $g = 1.45$ (CI: 0.81, 2.20). Sexual arousal to the low-intensity sexual stimulus category was not higher than to the nonsexual interaction stimulus category (or the neutral condition baseline) in the cover-off, $g = 0.46$ (CI: –0.04, 1.00), and cover-on, $g = 0.47$ (CI: –0.28, 1.25), conditions, as demonstrated by the confidence intervals that included zero. As expected, women did not report feelings of sexual arousal to the neutral condition baseline or to the nonsexual interaction (mean arousal ratings close to 0) and there was no difference in sexual arousing ratings between these 2 categories in the cover-off, $g = –0.15$ (CI: –0.64, 0.32), or cover-on condition, $g = –0.07$ (CI: –0.65, 0.51), conditions. Patterns of self-reported sexual

arousal in the cover-off and cover-on conditions were related, as indicated by the within-subjects correlation between self-report ratings in the cover-off and cover-on conditions across all 7 stimulus presentations, $r(22) = .88$ (95% CI: 0.79 to 0.93).

Genital Response

The bottom portion of Figure 4.3 shows the mean-minus-baseline VPA in mV for each stimulus category in the cover-off and cover-on conditions (the mean and SD are reported for each stimulus category in the Figure). A 2 (condition: cover-off, cover-on) × 4 (stimulus category: neutral baseline, nonsexual interaction, low-intensity sexual, high-intensity sexual) within-subjects ANOVA was conducted with VPA as the DV. Overall, there was a main effect of stimulus category, $F(2.00, 47.94) = 70.06$, $\eta_p^2 = .75$ (90% CI: 0.62 to 0.80), Greenhouse-Geisser $\varepsilon = .67$. There was no main effect of condition, $F(1, 24) = 2.53$, $\eta_p^2 = .10$ (CI: 0.00, 0.29), and no interaction between condition and stimulus category, $F(2.20, 52.94) = 1.16$, $\eta_p^2 = .04$ (CI: 0.00, 0.14), Greenhouse-Geisser $\varepsilon = .74$. To account for a potential confounding effect of hormonal contraceptive use on genital response,[65] we excluded women who were not using a hormonal contraceptive at the time of testing and obtained the same results.

When comparing the magnitude of response elicited by the same stimulus category in the cover-off and cover-on conditions, we see that mean-minus-baseline VPA was similar across conditions (CIs included zero): neutral condition baseline, $g = 0.30$ (95% CI: –0.17 to 0.78); nonsexual interaction, $g = 0.31$ (CI: –0.20, 0.85); low-intensity sexual, $g = –0.19$ (CI: –0.70, 0.22); high-intensity sexual, $g = 0.30$ (CI: –0.09, 0.69). The within-subjects correlation between genital responses in the cover-off and cover-on conditions across all stimuli was $r(23) = .75$ (95% CI: 0.65 to 0.83).

Despite the absence of an interaction between stimulus condition and stimulus category, we examined the effect of stimulus category within each condition. We conducted 2 separate

one-way within-subjects ANOVAs, with stimulus category as the within-subjects variable and VPA as the DV. There was a main effect of stimulus category for the cover-off condition, $F(1.83, 43.91) = 47.20$, $\eta_p^2 = .66$ (90% CI: 0.50 to 0.74), Greenhouse-Geisser $\varepsilon = .61$, and the cover-on condition, $F(2.30, 55.17) = 52.29$, $\eta_p^2 = .69$ (CI: 0.55, 0.75), Greenhouse-Geisser $\varepsilon = .77$.

Table 4.1 shows the Hedge's *g* effect sizes and 95% CI when comparing mean-minus-baseline VPA for different stimulus categories. In both conditions, the high-intensity sexual stimulus category elicited a greater change in VPA compared to all other categories and the effect sizes of the comparisons with the high-intensity sexual category were relatively large. Change in VPA was slightly stronger for the low-intensity sexual category compared to the nonsexual interaction in the cover-on condition. The effect size of the difference between the low-intensity sexual category and the nonsexual interaction was smaller in the cover-off condition than the cover-on condition. In both conditions, the low-intensity sexual category elicited greater VPA than the neutral baseline, although the size of the effect was smaller in the cover-off condition. The nonsexual interaction category elicited similar VPA to the neutral condition baseline in both conditions.

DISCUSSION

We placed a polyisoprene condom cover on the VPP probe and tested for potential effects on VPA and self-report data. Placing a disposable protective cover on the reusable VPP may be advantageous to the safety and comfort of participants, as well as to experimenters involved in its cleaning and disinfection. The possibility of encasing the VPP with a cover had been discussed among researchers in the field[47]; however the effect of doing so had not been tested in any known publications.

The magnitude of genital response and self-reported sexual arousal for each stimulus

category and the overall pattern of results were unaffected by the condom cover. There was a strong association between VPA in both conditions, despite the small number of data points (7 pairs of data) in the within-subjects correlation. Placing a protective cover on the VPP probe did not appear to impact the number of artifacts in the VPA data. Based on visual inspection, VPP waveform morphology appeared similar across conditions. These findings suggest that potential effects of a VPP cover on light diffusion and reflection are minimal and do not jeopardize the data. Participants expressed no concerns with the condom cover in their written responses on the feedback questionnaire and verbal responses during the experiment debriefing, and they reported no difference in the use or comfort of the VPP between the cover-off and cover-on conditions.

Across all participant trials, including those that were excluded from the analyses (420 total), 4 trials in the cover-on condition and 0 in the cover-off condition were excluded for excessive movement artifacts in the VPP data. Given the low base rate of trials affected by excessive movement artifacts in the cover-on condition (4 of the 210 cover-on trials or 1.9%), it seems unlikely that the higher number of movement artifacts in the cover-on condition was due to interference from the cover. In support of this hypothesis, trial baselines affected by artifacts were no more common in the cover-on condition (one trial baseline in each condition). Also, data exclusion due to a problematic VPP signal across all trials in a given condition occurred for one participant in each condition. Data from another woman were excluded because of non-responding—defined as no increase in VPA to any experimental trial relative to the condition baseline—in the cover-on condition; however, the participant responded minimally in the cover-off condition (± 0.12–0.7 mV relative to the condition baseline), suggesting that her lack of VPA responding was not attributed to the presence of the cover. Replication research is required to rule-out the possibility that the protective cover affects VPP signal quality, but these initial results suggest that a condom cover does not interfere with the VPP signal.

One potentially meaningful difference between conditions was that the increase in VPA elicited by the low-intensity stimulus category compared to the neutral condition baseline and the nonsexual interaction was larger in the cover-on versus cover-off condition, as demonstrated by the larger effect sizes in the cover-on condition, possibly suggesting that the effect of erotic intensity was more prominent in the cover-on condition. One interpretation of this finding is that the cover facilitated detection of minute responses and enhanced the sensitivity of the VPP, although there is no theoretical basis for this idea. It is also possible that women were more comfortable or relaxed with the cover, which facilitated responses to the low-intensity stimuli; this effect may have been less noticeable with intercourse stimuli because the higher intensity overwhelmed the vaginal response. Measures of state affect (eg, degree of relaxation, interest, anxiety) were not included before or after stimulus presentations and so it is unknown whether affective responses differed across conditions; however, meaningful differences in state affect seem unlikely given the similarity of self-reported sexual arousal across conditions and the responses on the feedback questionnaire. A parsimonious explanation for the stronger response to the low-intensity stimuli in the cover-on condition is that it was a spurious finding; that is, the magnitude of the difference across conditions was not meaningful. This is supported by the finding that there was no interaction between experimental condition and stimulus category. Regardless of the explanation, the finding of an intensity effect (as hypothesized) in the cover-on condition further supports the conclusion that the cover did not jeopardize the VPP signal and data.

The effect of the low-intensity sexual stimuli on VPA appeared to be smaller than in previous research (direct comparisons with the Chivers et al[5] study were not possible because the data were standardized). Female nude exercise may not have been as sexually relevant for participants in the current study compared to those in the Chivers et al[5] study. This is evidenced

by the self-reported sexual arousal ratings in the present study, which were comparable for the nonsexual interaction and low-intensity sexual stimulus categories. Other researchers have also found that stimulus categories selected to elicit different degrees of sexual arousal do not always produce intensity effects in self-report or genital data.[52,66] The elaborative processing that influences the degree to which a cue or collection of cues (eg, audiovisual stimulus) is appraised as sexual depends on its affective meaning in memory (information processing model of sexual response[67]). Given generational and age cohort differences in sexual attitudes and behaviours, and pornography consumption,[68,69] the extent to which female nude exercise is sexually salient or evocative may have also changed over time. To our knowledge, generational or time period effects on genital responsivity to sexual stimulus categories have not been tested.

In the current study, participants were instructed to apply a small amount of silicone-based personal lubricant on the probe to facilitate insertion. The effect of the personal lubricant on the VPP data was not directly tested (the lubricant was used in each condition); however, data comparison with recent research in our lab suggests that the lubricant did not affect the magnitude of the response or the number of artifacts. For instance, mean VPA for the neutral (mean = 1.6 mV, SD = 1.0) and high-intensity sexual intercourse (mean = 3.4 mV, SD =1.4) categories in the current study (cover-off condition) were highly comparable to those reported by Dawson et al[8] for their neutral nonsexual (mean = 1.6 mV, SD =1.5) and male–female intercourse (mean = 3.5 mV, SD = 2.8) categories (the stimuli in the current study were abbreviated versions of the films used in Dawson et al[8]). The number of artifacts per minute per participant in the current study was also comparable to other studies in our laboratory.[52] Although comparisons between the current study and other research in our lab support the idea that the personal lubricant did not meaningfully impact the VPA data, we recognize that comparing VPA signal values (in mV) across studies is precarious given that mV is a relative

scale. The availability of a personal lubricant may be advantageous for studies involving participants who experience vaginal dryness (eg, post-menopausal women). The purpose of the personal lubricant in the current study was for consistency across experimental conditions because the condoms were pre-lubricated. Use of a personal lubricant is not necessary for studies in which a condom cover is used for all experimental trials; basal vaginal wetness is sufficient for VPP insertion for women who do not experience vaginal dryness. Participants' feedback regarding the lubricant was variable. It was described as both "helpful" and as "unnecessary," and 2 participants reported concern that the VPP would be extruded ("slip out") due to the lubricant.

One limitation of the current study is that we did not control for the amount of personal lubricant that the participants used in each condition. Participants were instructed to use a "dime-sized" amount, but variability across participants is possible. Given the similarity of the VPA magnitude and overall pattern of responses in both conditions, any difference in the amount of lubricant minimally impacted the data. Future researchers who incorporate the use of personal lubricant may wish to better control the amount used in order to reduce random error, particularly if there are multiple conditions (as in the current study) or a between-subjects design. A disadvantage of an exogenous lubricant is that it may interfere with participants' self-assessment of genital arousal: One woman noted in her study feedback questionnaire that it was difficult to assess and rate her perceived genital arousal due to the lubricant.

VPA sampling rates are variable across psychophysiological studies. In our laboratory and others,[10,52,65] VPA is recorded at 10 Hz (ie, 10 samples/s), which is thought to be sufficient to capture the signal of interest,[20] whereas other laboratories use higher sampling rates (eg, 200 samples/s[70,71]). A higher frequency sampling rate facilitates the detection of additional artifacts and peaks and may have provided a more rigorous examination of differences in signal quality

between the cover-off and cover-on conditions. Sampling rate ought to be considered and reported in psychophysiological research and inter-laboratory standardization is recommended.

It is recommended that a smaller diameter cover that fits tighter against the probe be designed and tested. Excess material may result in folds (as shown in Figure 4.1), which could potentially affect light reflectance (this was not tested in the current study). Use of condoms with excess material may be an issue for studies where the VPP is removed and reinserted because doing so could disrupt the material and create random errors. Condoms made with thinner material may also be tested. Polyisoprene is slightly thicker than latex; however, SKYN® recently released the Elite style (5.3 cm width), which is 20% thinner than the Original style (https://www.skyn.com/en-us/condoms/). It is also unknown at this time whether a VPP cover could disrupt the signal when using alternative data collection and processing hardware (eg, BIOPAC Systems) or software (e.g. AcqKnowledg, Matlab), or VPP devices from other manufacturers.

CONCLUSION

VPP is the most widely used measure of genital response and offers many advantages over other instruments (eg, ease of use, quick response detection, speed of return to baseline, comparison across multiple stimulus presentations in one session).[25,27] Encasing the VPP with a disposable cover promotes health and safety because the reusable probe does not come into direct contact with the genitals. The cover offers added protection from STIs, such as HPV infections, which are known to be inactivation-resistant even to high-level disinfection.[36,37] The added protection of a cover may be incremental, particularly if eligibility criteria specify that persons with an active STI are ineligible and if the VPP is disinfected with Cidex and sodium lauryl sulphate. Indeed, there are no documented cases of cross-infection in VPP studies. However, given that some STIs are associated with severe adverse outcomes (eg, cancer-risk

associated with HPV infection)[39] and can be asymptomatic (eg, some types of HPV),[40] researchers may wish to carefully consider their disinfection practices and how they manage risk in relation to VPP disinfection. The use of a cover complies with current reprocessing guidelines and standards specifying that semi-critical medical devices, such as endocavitary (ie, vaginal, anal, oral) ultrasound probes, be covered with a single-use barrier, such as a sheath or condom.[44,46]

Potential disadvantages of the cover include the additional cost (approximately $1.50 CDN per participant in our study) and time to prepare the VPP before use and to properly dispose of the cover after use (estimated to be approximately five minutes). These costs may be outweighed by the benefits to participant health and safety, particularly if studying populations at high-risk of STIs or women who may be immunocompromised and at higher risk for infection (eg, women with cancer). The cover is not a substitute for high-level disinfection and there is a potential risk of perforation. Researchers may wish to also consider other disinfection or sterilization procedures that have demonstrated efficacy in deactivating HPV (eg, sonicated hydrogen peroxide, high-level ultra-violet C radiation).[36,38,47]

In addition to minimizing potential health risks (eg, transmission of disease or infection), there may be psychological advantages of a VPP cover, such as enhanced participant comfort and willingness to participate. The use of a cover does not necessarily mean that all women will be more comfortable with VPP (the majority of women in Huberman et al[48] who did not want to participate in a VPP study cited more general reasons), but it could be a mollifying factor for some women as it communicates to participants that their safety is paramount. Reducing barriers to participation may help researchers recruit a larger and more diverse sample of participants, which could strengthen the generalizability of VPP results. For these reasons, it may be advantageous for sexual psychophysiological researchers to begin using a disposable protective

cover on the VPP.

REFERENCES

1. Janssen E. Psychophysiological measurement of sexual arousal. In: Wiederman MW, Whitley BE, editors. Handbook for conducting research on human sexuality. Mahwah (NJ): Erlbaum; 2002. p. 139-171.

2. Levin RJ. The mechanisms of human female sexual arousal. Annu Rev Sex Res 1992;3:1-48.

3. Masters WH, Johnson VE. Human sexual response. Boston: Little, Brown & Co; 1966.

4. Chivers ML, Bouchard KN, Timmers AD. Straight but not narrow; Within-gender variation in the gender-specificity of women's sexual response. PLoS One 2015;10:e0142575.

5. Chivers ML, Seto MC, Blanchard R. Gender and sexual orientation differences in sexual response to sexual activities versus gender of actors in sexual films. J Pers Soc Psychol 2007;93:1108-1121.

6. Suschinsky KD, Lalumière ML, Chivers ML. Sex differences in patterns of genital sexual arousal: Measurement artifacts or true phenomena? Arch Sex Behav 2009;38:559-573.

7. Lalumière ML, Fairweather A, Harris GT, et al. Genital responses to rape vignettes among young men: The influence of mood and directed attention. Arch Sex Behav 2017;46:685-695.

8. Dawson SJ, Sawatsky ML, Lalumière ML. Assessment of introital lubrication. Arch Sex Behav 2015;44;1527-1535.

9. Gerritsen J, van der Made F, Bloemers J, et al. The clitoral photoplethysmograph: A new way of assessing genital arousal in women. J Sex Med 2009;6:1678-1687.

10. Huberman JS, Chivers ML. Examining gender specificity of sexual response with concurrent thermography and plethysmography. Psychophysiology 2015;52:1382-1395.

11. Meuwissen I, Over RO. Sexual arousal across phases of the human menstrual cycle. Arch Sex Behav 1992;21:101-119.

12. Seal BN, Brotto LA, Gorzalka BB. Oral contraceptive use and female genital arousal:

Methodological considerations. J Sex Res 2005;42:249-258.

13. Lalumière ML, Quinsey VL. Harris GT, et al. Are rapists differentially aroused by coercive sex in phallometric assessments? Ann N Y Acad Sci 2003:989:211-224.

14. Boolell S, Gepi-attee S, Gingell JC, et al. Sildenafil, a novel effective oral therapy for male erectile dysfunction. Br J Urol 1996;78:257-261.

15. Brauer M, Laan E, ter Kuile MM. Sexual arousal in women with superficial dyspareunia. Arch Sex Behav 2006;35:187-196.

16. Geer JH, Morokoff P, Greenwood P. Sexual arousal in women: The development of a measurement device for vaginal blood volume. Arch Sex Behav 1974;3:559-64.

17. Sintchak G, Geer JH. A vaginal plethysmography system. Psychophysiology 1975;12:113-5.

18. Palti Y, Bercovici B. Photoplethysmographic study of the vaginal blood pulse. Am J Obstet Gynecol 1967;97:143-153.

19. Hoon PW, Wincze JP, Hoon EF. Physiological assessment of sexual arousal in women. Psychophysiology 1976;13:196-204.

20. Prause N, Janssen E. Blood flow: Vaginal photoplethysmography. In: Goldstein I, Meston CM, Davis S, Traish A, editors. Women's sexual function and dysfunction: Study, diagnosis and treatment, London: Taylor & Francis Medical Books; 2005, p. 361-369.

21. Heiman JR. A psychophysiological exploration of sexual arousal patterns in females and males. Psychophysiology 1977;14:266-274.

22. Laan E, Everaerd W, Evers A. Assessment of female sexual arousal: Response specificity and construct validity. Psychophysiology 1995;32:476-485.

23. Osborne CA, Pollack RH. The effects of two types of erotic literature on physiological and verbal measures of female sexual arousal. J Sex Res 1977;13:250-256.

24. Hatch JP. Vaginal photoplethysmography: Methodological considerations. Arch Sex Behav

1979;8:357-374.

25. Janssen E. Psychophysiological measurement of sexual arousal. In: Wiederman MW, Whitley BE, editors. Handbook for conducting research on human sexuality, Mahwah (NJ): Erlbaum; 2002. p. 139-171.

26. Kukkonen TM. What is the best method of measuring the physiology of female sexual arousal? Curr Sex Health Rep 2014;6:30-37.

27. Woodard TL, Diamond MP. Physiologic measures of sexual function in women: A review. Fertility and Sterility 2009;92:19-34.

28. Prause N, Williams K, Bosworth K. Wavelet denoising of vaginal pulse amplitude. Psychophysiology 2010;47:393-401.

29. Levin RJ, Wylie K. Vaginal vasomotion—its appearance, measurement, and usefulness in assessing the mechanisms of vasodilatation. J Sex Med 2008;5:377-386.

30. Chivers ML, Rieger G, Latty E, et al. A sex difference in the specificity of sexual arousal. Psychol Sci 2004;15:736-744.

31. Dawson SJ, Huberman JS, Bouchard KN, et al. Effects of individual difference variables, gender, and exclusivity of sexual attraction on volunteer bias in sexuality research. Arch Sex Behav 2019;48:2403-2417.

32. Geer JH. Sterilization of genital devices. Psychophysiology 1978;15:385.

33. Janssen E, Prause N, Geer JH. The sexual response. In: Cacioppo TJ, Tassinary LG, Berntson GG, editors. Handbook of psychophysiology. 3rd ed. New York: Cambridge University Press; 2007. p. 245-266.

34. Ontario Agency for Health Protection and Promotion. Best practices for cleaning, disinfection and sterilization of medical equipment/devices in all health care settings, 3rd edition. Available at: https://ipac-canada.org/evidence-based-guidelines.php. Accessed November 30,

2018.

35. Rutala WA, Weber DJ. Guideline for disinfection and sterilization in healthcare facilities. Available at: https://www.cdc.gov/infectioncontrol/guidelines/disinfection/authors.html. Accessed November 30 November, 2018.

36. Meyers C, Milici J, Robison R. UVC radiation as an effective disinfectant method to inactivate human papillomaviruses. PLoS One 2017;12:e0187377.

37. Meyers J, Ryndock E, Conway MJ, et al. Susceptibility of high-risk human papillomavirus type 16 to clinical disinfectants. J Antimicrob Chemother 2014;69:1546-1550.

38. Ryndock E, Robison R, Meyers C. Susceptibility of HPV16 and 18 to high level disinfectants indicated for semi-critical ultrasound probes. J Med Virol 2016;88:1076-1080.

39. Trottier H, Franco EL. The epidemiology of genital human papillomavirus infection. Vaccine 2006;24:S4-S15.

40. Unemo M, Bradshaw CS, Hocking JS, et al. Sexually transmitted infections: Challenges ahead. Lancet Infect Dis 2017;17:e235-e279.

41. Fisher CW, Fiorello A, Shaffer D, et al. Aldehyde-resistant mycobacteria bacteria associated with the use of endoscope reprocessing systems. Am J Infect Control 2012;40:880-882.

42. Howett MK, Neely EB, Christensen ND, et al. A broad-spectrum microbicide with virucidal activity against sexually transmitted viruses. Antimicrob Agents Chemother 1999;43:314-321.

43. Piret J, Desormeaux A, Bergeron MG. Sodium lauryl sulfate, a microbicide effective against enveloped and nonenveloped viruses. Curr Drug Targets 2002;3:17-30.

44. Basseal JM, Westerway SC, Juraja M, et al. Guidelines for reprocessing ultrasound transducers. Australas J Ultrasound Med 2017;20:30-40.

45. Canadian Society of Diagnostic Medical Sonography. Professional practice guidelines and policy statements for Canadian sonography. Available at: https://www.sonographycanada.ca/

apps/sites-management/filedownload/datadownload/6945/csdms_professionalpractice_e_/pdf/1/1033. Accessed February 26, 2019.

46. College of Physicians and Surgeons of British Columbia. Reprocessing requirements for ultrasound probes. Available at: https://www.cpsbc.ca/files/pdf/Reprocessing-Requirements-Ultrasound-Probes.pdf. Accessed February 26, 2019.

47. Carrito ML, Tavares IM, Pereira R, et al. Cleaning procedures of genital measures in Sexlabs: Current practices and emerging challenges. Proceedings of the 24th Congress of the World Association for Sexual Health; 2019 Oct 12-15; Mexico City, Mexico.

48. Huberman JS, McInnis MK, Bouchard KN, et al. Exploring comfort levels and the role of compensation in sexual psychophysiology study participation. Arch Sex Behav 2019;48:2389-2402.

49. Bouchard KN, Stewart JG, Boyer SC, et al. Sexuality and personality correlates of willingness to participate in sex research. Can J Hum Sex 2019;28:26-37.

50. Plaud JJ, Gaither GA, Hegstad HJ, et al. Volunteer bias in human psychophysiological sexual arousal research: To whom do our research results apply? J Sex Res 1999;36:171-179.

51. Strassberg DS, Lowe K. Volunteer bias in sexuality research. Arch Sex Behav 1995; 24: 369–382.

52. Sawatsky ML, Dawson SJ, Lalumière ML. Genital lubrication: A cue-specific sexual response? Biol Psychol 2018;134:103-113.

53. Kinsey AC, Pomeroy WB, Martin CE, et al. Sexual behaviour in the human female. Philadelphia, PA: Saunders; 1953.

54. Fairweather A, Kingston DA. Lalumière ML. Nudity as a disinhibiting cue in a date rape analogue. Arch Sex Behav 2015;45:821-828.

55. Rooks VJ, Yancey MK, Elg, SA, et al. Comparison of probe sheaths of endovaginal

sonography. Obstet Gynecol 1997;87:27-29.

56. Dezzutti CS, Brown ER, Moncla B, et al. Is wetter better? An evaluation of over-the-counter personal lubricants for safety and anti-HIV-1 activity. PLoS One 2012:7:e48328.

57. Herbenick D, Reece M, Hensel D, et al. Association of lubricant use with women's sexual pleasure, sexual satisfaction, and genital symptoms: A prospective daily diary study. J Sex Med 2011;8:202-212.

58. Meston CM, Gorzalka BB. Differential effects of sympathetic activation on sexual arousal in sexually dysfunctional and functional women. J Abnorm Psychol 1996;105:582-591.

59. Huberman JS, Suschinsky KD, Lalumière ML, et al. Relationship between impression management and three measures of women's self-reported sexual arousal. Can J Behav Sci 2013;45:259-273.

60. Smithson M. Scripts and software for noncentral confidence interval and power calculations. Available at: http://www.michaelsmithson.online/stats/CIstuff/CI.html. Accessed July 12, 2018.

61. Smithson M. Correct confidence intervals for various regression effect sizes and parameters: The importance of noncentral distributions in computing intervals. Educ Psychol Meas 2001;61:605-632.

62. Lakens D. Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. Front Psychol 2013;4:1-12.

63. Borenstein M, Hedges LV, Higgins JPT, et al. Introduction to meta-analysis. West Sussex, UK: John Wiley & Sons, Ltd.; 2009.

64. O'Brien F, Cousineau D. Representing error bars in within-subject designs in typical software packages. Tutor Quant Methods Psychol 2014;10:56-67.

65. Seal BN, Brotto LA, Gorzalka BB. Oral contraceptive use and female genital arousal: Methodological considerations. J Sex Res 2005;42:249-258.

66. Bouchard KN, Chivers, ML, Pukall CF. Effects of genital response measurement device and stimulus characteristics on sexual concordance in women. J Sex Res 2017;54:1197-1208.

67. Janssen E, Everaerd W, Spiering M, et al. Automatic processes and the appraisal of sexual stimuli: Toward an information processing model of sexual arousal. J Sex Res 2000;37:8-23.

68. Price J, Patterson R, Regnerus M, et al. How much more XXX is generation X consuming? Evidence of changing attitudes and behaviors related to pornography since 1973. J Sex Res 2016;53:12-20.

69. Twenge JM, Sherman RA, Wells BE. Changes in American adults' sexual behavior and attitudes, 1972–2012. Arch Sex Behav 2015;44:2273-2285.

70. Pulverman CS, Hixon JG, Meston CM. Uncovering category specificity of genital sexual arousal in women: The critical role of analytic technique. Psychophysiology 2015;10:1396-1408.

71. Velten J, Chivers ML, Brotto LA. Does repeated testing impact concordance between genital and self-reported sexual arousal in women? Arch Sex Behav 2018;47:651-660.

Table 4.1

Effect Sizes of the Difference in VPA Between Stimulus Categories for the Cover-Off (Above Diagonal) and Cover-On (Below Diagonal) Conditions

Stimulus Category	Neutral Baseline	Nonsexual Interaction	Low-Intensity Sexual	High-Intensity Sexual
Neutral Baseline		0.31 (-0.23, 0.88)	**0.57 (0.11, 1.07)**	**2.69 (1.51, 4.04)**
Nonsexual Interaction	0.42 (-0.18, 1.06)		0.26 (-0.14, 0.69)	**2.54 (1.49, 3.76)**
Low-Intensity Sexual	**1.65 (0.65, 2.77)**	**0.93 (0.23, 1.69)**		**2.48 (1.41, 3.72)**
High-Intensity Sexual	**2.65 (1.45, 4.03)**	**2.40 (1.20, 3.76)**	**1.84 (1.06, 2.75)**	

Note. Effect sizes represent Hedge's *g*. Numbers in brackets represent 95% CIs of *g*. When a 95% CI does not cross zero, values are displayed in bold. CI = confidence interval; VPA = vaginal pulse amplitude.

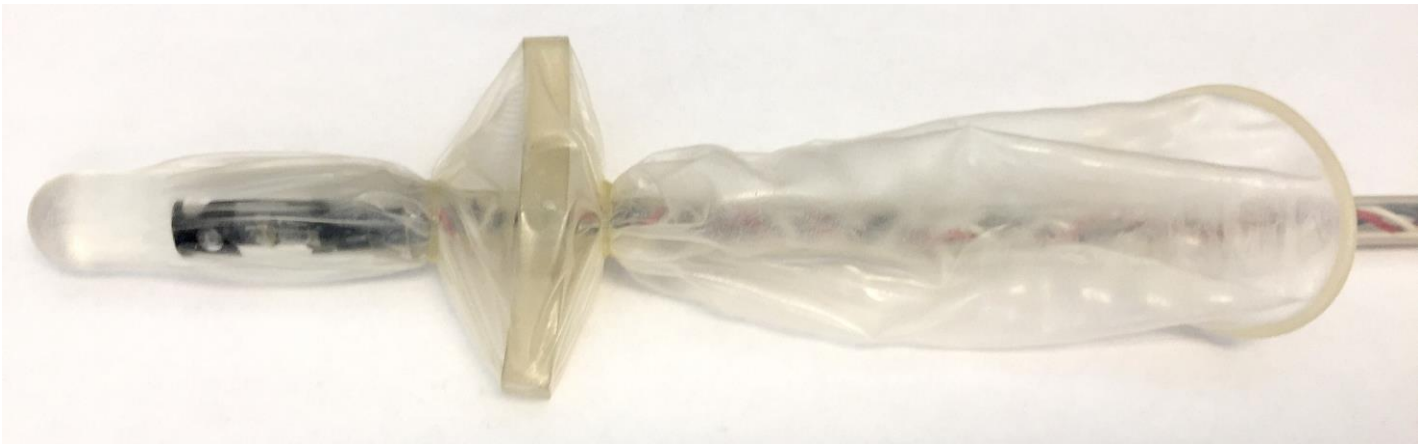

Figure 4.1. An image of the vaginal photoplethysmograph probe with the condom cover.

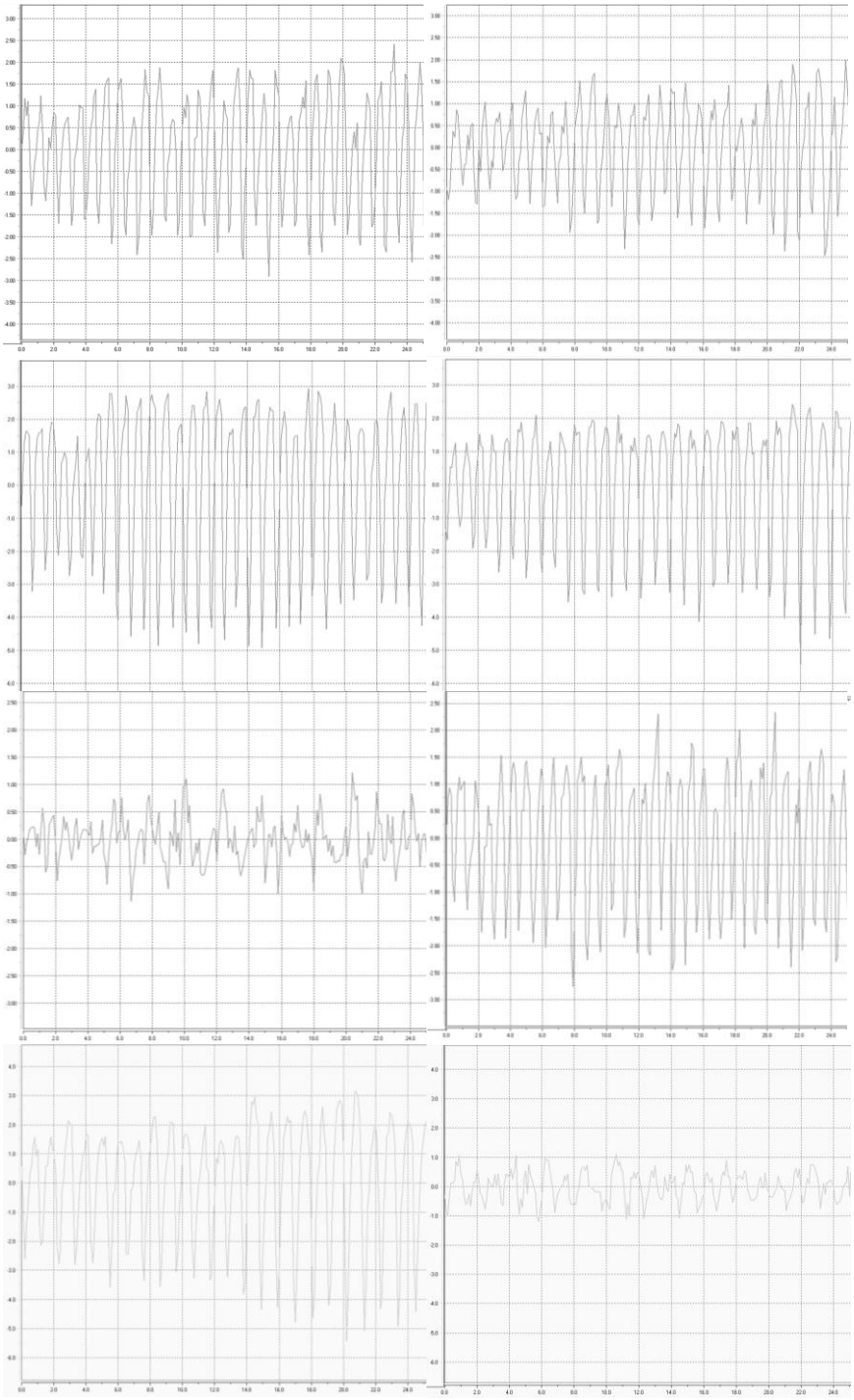

Figure 4.2. Example VPA data in mV (y-axis) across 25 s (x-axis) for a high-intensity sexual stimulus in the cover-off (left) and cover-on (right) conditions for two participants with useable data (top two rows) and two participants whose data were excluded due to problematic waveforms (bottom two rows). The y-axis varies by participant due to individual differences in VPA amplitudes. VPA = vaginal pulse amplitude.

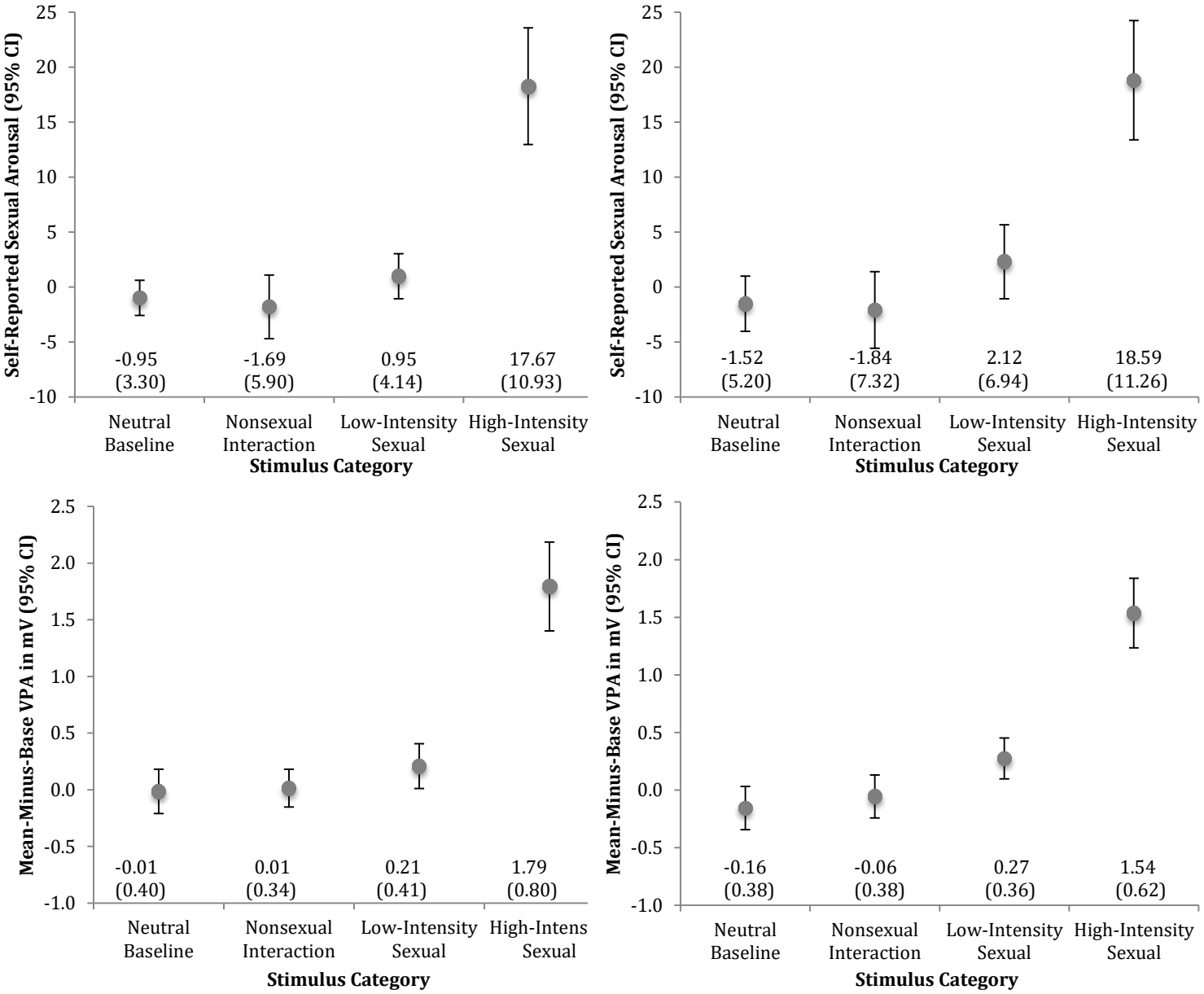

Figure 4.3. Change in continuous self-reported sexual arousal (top) and change in VPA (bottom) in the cover-off (left) and cover-on (right) conditions. Error bars represent 95% CI. Numerical values below each data point represent the mean and SD (in parentheses) for each stimulus category. SD = standard deviation; VPA = vaginal pulse amplitude.

CHAPTER 5

Can the Vaginal Photoplethysmograph and its Associated Methodology be Used to Assess Intra-Anal Vasocongestion in Women and Men?

Abstract

Forty years ago, researchers documented changes in vascular and muscular activity within the anal canal of women and men who engaged in sexual self-stimulation. Vascular changes were assessed using a photoplethysmograph that aimed to detect changes in pelvic vasocongestion. An important advantage of detecting sexual response within the anal canal is that the device, its anatomical placement, and the data output are identical for women and men. In this study, the vaginal photoplethysmograph (VPP), the most common measure of sexual response in women, was administered intra-anally as an anal photoplethysmograph (APG) to examine its validity and sensitivity as an indicator of sexual response. The final sample comprised 20 women and 20 men who were exposed to 12, 90-s sexual and nonsexual film clips while their physiological sexual response was assessed with the APG. Participants also rated their sexual arousal and affective responses to the stimuli. There was evidence that the APG was sensitive to erotic intensity and was specific to sexual stimuli in women. The degree of discrimination between sexual and nonsexual stimuli was lower in men. Unlike most sexual psychophysiological studies, the positive correlation between physiological and self-reported sexual arousal was stronger in women than in men. There was a relatively high number of data artifacts and the waveform morphology was uncharacteristic of that typically observed with VPP. The potential role of anal musculature interference on the APG signal is discussed, as well as avenues for future research.

A popular and important area of inquiry in sexual psychophysiology research and sex research more broadly is the examination of gender/sex differences and similarities (e.g., see meta-analyses and reviews by Chivers, Seto, Lalumière, Laan, Grimbos, 2010; Peterson & Hyde, 2010; Oliver & Hyde, 1993; Rupp & Wallen, 2008). Using instruments to quantify physiological and affective responses to sexual stimuli in the laboratory, a gender/sex difference has been observed in the stimulus features or cues that influence the magnitude of genital response in women and men (e.g., Chivers, Rieger, Latty, & Bailey, 2004; Chivers, Roy, Grimbos, Cantor, & Seto, 2014; Chivers & Timmers, 2012; Suschinsky, Lalumière, & Chivers, 2009). Differences in genital anatomy have necessitated the use of different measurement devices and methodologies for women and men that are not necessarily comparable. This raises the question of whether the observed discrepancies in women and men's genital response patterns are measurement artifacts or are true phenomena. To address this question, we tested whether a photoplethysmograph that is commonly used intra-vaginally to measure genital response in women could be used intra-anally to detect a sexual response in women and men. An advantage of quantifying sexual responses with anal photoplethysmography is that it can assess physiological responding in the same anatomical region (i.e., anal canal) and in the same manner in women and men. If the anal photoplethysmograph is a valid measure of sexual response, it may be an optimal method to investigate gender/sex differences in sexual response patterns.

Cue-Specificity

Cue-specificity refers to the degree of differentiation in sexual responses to various sexual cues and is described in relative terms (i.e., to another person or group; Lalumière, 2017). A gender/sex difference has been observed in the degree of cue-specificity that women and men exhibit in response to gender/sex cues, particularly when comparing the genital responses of men and androphilic women. Gender refers to the behaviors or traits associated with femininity or

masculinity in a particular culture, and sex refers to the genitals and secondary sex characteristics related to femaleness or maleness (van Anders, 2015, recommends the term gender/sex in contexts when gender and sex cannot be disentangled).

Women of all sexual orientations produce substantial genital responses to both female and male gender/sex cues, regardless of the degree of self-reported sexual arousal elicited by the sexual stimuli (e.g., Chivers et al., 2004; Chivers, Seto, & Blanchard, 2007; see reviews by Chivers, 2017; Lalumière, Sawatsky, Dawson, & Suschinsky, 2020). For androphilic women (i.e., sexually attracted to men), there is little differentiation in the magnitude of genital response to audiovisual and audio-narrative sexual stimuli portraying male or female sexual targets (i.e., low gender/sex cue-specificity; e.g., Bossio, Suschinsky, Puts, & Chivers, 2014; Chivers & Bailey, 2005; Chivers, Roy, et al., 2014; Huberman & Chivers, 2015; Peterson, Janssen, & Laan, 2010; Sawatsky, Lavrinsek, Dawson, & Lalumière, 2020; Suschinsky et al., 2009; for exceptions see Pulverman, Hixon, & Meston, 2015; Sawatsky, Dawson, & Lalumière, 2018). In most studies, women who are gynephilic (i.e., sexually attracted to women) and androgynephilic (i.e., sexually attracted to women and men) exhibit greater gender/sex cue-specificity than androphilic women, with more elevated genital responses observed for female versus male sexual targets (Bouchard, Timmers, Chivers, 2015; Chivers, Bouchard, & Timmers, 2015; Timmers, Bouchard, & Timmers, 2015; for exceptions see Peterson et al., 2010; Pulverman et al., 2015); however, the degree of response discrimination remains lower compared to men (Chivers et al., 2007; Rieger et al., 2015).

Men, on average, exhibit genital responses to sexual cues that correspond with self-reported sexual arousal and sexual orientation preferences, and nonpreferred sexual cues elicit small, if any, genital response (e.g., Chivers et al., 2004; Sakheim, Barlow, Beck, & Abrahamson, 1985; Suschinsky et al., 2009). In other words, men demonstrate higher gender/sex

cue-specificity relative to women. Gender/sex cues, therefore, seem more salient or relevant to men's genital response, particularly when compared to androphilic women.

Although gender/sex cues have been a focus of cue-specificity research, it is noteworthy that other types of cues also produce gender/sex differences in genital response cue-specificity. Androphilic women, but not gynephilic men, exhibit a genital response to nonconsensual and/or violent sexual stimuli, yet both sexes rated these stimuli as unpleasant, anxiety-provoking, and minimally sexually arousing (Suschinsky & Lalumière, 2011a, 2011b). Androphilic women who report sexual interest and arousal to only conventional sex produce a substantial genital response to sexual stimuli depicting masochistic sex, whereas men with conventional sexual interests do not respond to this stimulus category (Chivers, Roy, et al., 2014). When presented with mating primates, neither men nor women report an increase in sexual arousal, yet women produce a small genital response and men do not (Chivers & Bailey, 2005; Chivers et al., 2007). Although any sexual cue seems to elicit a genital response in women, the magnitude of response is affected by other stimulus features such as the intensity of sexual activity (e.g., Chivers et al., 2007; Suschinsky et al., 2009; for exceptions see Bouchard, Chivers, & Pukall, 2017; Sawatsky et al., 2018) and other contextual cues (e.g., relationship context; Chivers & Timmers, 2012). In two studies, gender/sex cue-specificity among androphilic women was demonstrated when still images containing minimal contextual information were presented, highlighting the relevance of contextual cues for androphilic women's genital response (Spape et al., 2014; Timmers, 2019).

Assessment of Cue-Specificity

Common Measures of Genital Response

Gender/sex comparisons in genital response cue-specificity are typically made using devices that measure, or are purported to measure, genital vasocongestion (Chivers, Suschinsky, Timmers, & Bossio, 2014; Janssen, 2002; Janssen & Prause, 2016; Kukkonen, 2014, 2015).

Upon sexual arousal, more arterial blood flows to the genital structures (vagina, clitoris, labia, penis) than leaves in the veins, which produces vasocongestion or engorgement of the tissues—an indicator of sexual arousal in both women and men (Levin & Riley, 2007). Vasocongestion of the vaginal canal and penile shaft have been the principal focus of measurement in sexual psychophysiological studies.

The most common measures of genital vasocongestion are the vaginal photoplethysmograph (VPP) and the penile plethysmograph (PPG). The VPP is a tampon-sized intra-vaginal device that emits light and records backscattered light to assess changes in vaginal pulse amplitude (VPA) within the tissues that surround the vaginal canal (increased light reflectance is thought to indicate greater vasocongestion; Prause & Janssen, 2005). The PPG involves a strain gauge placed around the mid-shaft of the penis to assess changes in penile tumescence, or a tube placed over the penis to assess changes in air pressure caused by erection (Kuban, Barbaree, & Blanchard, 1999). Both measures have good psychometric properties (review by Janssen & Prause, 2016). PPG and VPP are specific measures of sexual stimulation that consistently differentiate between sexual stimuli and those that induce other affective states (e.g., excitement, anxiety; Laan, Everaerd, & Evers, 1995; Suschinsky et al., 2009).

A limitation of investigating gender/sex differences in sexual response patterns using VPP and PPG is that the devices assess changes in vasocongestion at different anatomical regions and quantify the response using different measurement units and scales. VPP records VPA in millivolts (mV) and PPG measures penile circumference in millimeters (mm) or blood volume in milliliters (ml). Unlike the PPG, the VPP has a relative (not absolute) output scale and there is no standardized calibration protocol (Kukkonen, 2014, 2015; Prause & Janssen, 2005). Although VPP is purported to measure vaginal vasocongestion, this has not been proven (Prause & Janssen, 2005), whereas PPG assesses a more obvious and well-understood marker of sexual

response in men (penile erection). There is also evidence that the capacity for change in vasocongestion is different for female and male genitalia (Graziottin & Gambini, 2015), which could impede the comparability of these responses (this idea is further discussed below). Taken together, there are fundamental differences between PPG and VPP and the physiological process they are purported to measure, which can render between-gender/sex comparisons in sexual response patterns problematic. It is possible that the observed gender/sex differences in cue-specificity reflect the use of non-comparable measurement devices and methodologies that assess different aspects of physiological responding, rather than true gender/sex differences in genital response patterns.

Other Measures of Genital Vasocongestion

To address the limitations inherent in studying gender/sex differences using VPP and PPG, alternative technologies and methodologies have been used to examine genital response cue-specificity. The clitoral photoplethysmograph is a relatively new device that provides a relative measure of clitoral blood volume (CBV) or clitoral pulse amplitude (CPA). The clitoris is a homologous structure to the penis and upon sexual arousal the erectile tissues of the clitoral structures engorge with blood (Graziottin & Gambini, 2015). Assessing clitoral vasocongestion may, therefore, be a more appropriate comparison to penile responses measured with PPG.

Most studies have focused on testing the validity of the clitoral photoplethysmograph as a measure of sexual response (Gerritsen et al., 2009; Mechelmans et al., 2017; Suschinsky, Shelley, Gerritsen, Tuiten, & Chivers, 2015) and only one study has used it to investigate cue-specificity (Suschinsky, Dawson, & Chivers, 2020). Suschinsky et al. (2020) presented androphilic women with female and male masturbation stimuli and concurrently measured VPA and CBV with vaginal and clitoral photoplethysmography, respectively. Comparable VPA and CBV were elicited by female and male sexual stimuli; thus, low gender/sex cue-specificity was

observed with both measures. It is noteworthy, however, that women's sexual arousal ratings in this study did not differentiate between female and male sexual stimuli, leaving open the possibility that low cue-specificity for CBV was a function of low cue-specificity for self-reported sexual arousal. An advantage of using the clitoral photoplethysmograph to study gender/sex differences is that, theoretically, it assesses physiological changes that are relatively more comparable to those measured with the PPG; however, like the VPP, the clitoral photoplethysmograph and its data output cannot be directly compared to any existing measures of male genital response.

Thermography is an indirect measure of genital vasocongestion that involves a camera that detects infrared energy proportional to surface genital temperature. Higher temperatures are thought to reflect increased genital vasocongestion (Kukkonen, Binik, Amsel, & Carrier, 2007; Kukkonen, Binik, Amsel, & Carrier, 2010). Thermography has demonstrated good discriminant and convergent validity, with increases in genital temperature observed specifically in response to sexual stimuli (Kukkonen et al., 2007, 2010). Advantages of thermography in the investigation of gender/sex differences are that it assesses a similar physiological process (genital temperature change) in women and men and responses are quantified using the same absolute output scale (degrees Celsius; reviewed by Tavares et al., 2018).

Huberman and Chivers (2015) concurrently assessed genital response gender/sex cue-specificity with thermography and either VPP or PPG, and replicated the observed gender/sex difference in cue-specificity. For androphilic women, increases in genital temperature and VPA were observed in response to both female and male sexual stimuli (masturbation films), whereas gynephilic men showed increases in genital temperature and circumference to only the female stimuli. The analyses focused on temperature change of the left labia majora and the shaft of the penis, which are not homologous structures; however, the authors reported that a consistent

pattern of results was found when examining the clitoris and penile glans (homologous structures). Like the Suschinsky et al. (2020) clitoral photoplethysmography study, androphilic women's self-reported sexual arousal did not discriminate between female and male sexual stimuli (men rated the female sexual stimuli as much more sexually arousing than male stimuli). It is unknown whether genital temperature would exhibit greater cue-specificity if women were presented with multiple sexual stimuli that elicit variation in self-reported sexual arousal. The number of stimulus presentations is restricted when using thermography because relatively long-duration stimuli (600 s in Huberman & Chivers, 2015) are required to detect temperature change. Although thermography addresses some of the limitations inherent to VPP and PPG when investigating gender/sex differences in cue-specificity, there are noteworthy limitations. First, there is no consensus as to which genital areas (if any) are appropriate to compare for women and men. Also, temperature change is an indirect measure of genital vasocongestion that appears to have a greater capacity for change in men; therefore, only relative comparisons are advised (Chivers, 2017; Huberman & Chivers, 2015).

Laser Doppler imaging (LDI) is a direct measure of external genital vasocongestion that assesses superficial perfusion (i.e., blood flow to the tissues) up to a depth of 2–3 mm below the skin surface (Styles, Maclean, Reid, & Sultana, 2006). The imaging machine scans the area of interest with an infrared laser; the amount of backscattered light is detected and processed to produce an image where the continuum of colors corresponds to the amount of blood flow. The unit of measurement (flux) represents the product of the mean velocity and concentration of moving blood cells in the area of interest (Styles et al., 2006). The flux unit is absolute, facilitating group comparisons (e.g., Boyer, Pukall, & Chamberlain, 2013).

LDI has demonstrated specificity for sexual response (Waxman & Pukall, 2009) and test-retest reliability (Styles et al., 2006). Areas of interest have included the whole vulvar area or

specific structures (e.g., labia, fourchette, or clitoral hood; Bouchard et al., 2017; Bouchard, Dawson, Shelley, & Pukall, 2019; Boyer et al., 2013, 2019; Styles et al., 2006; Waxman & Pukall, 2009). Until recently, it was not clear whether LDI could be used to assess penile vasocongestion due to potential image distortion resulting from changes in the size and angle of the penis (Kukkonen, 2014). Bossio, Singh, and Pukall (2018) tested the LDI in men and found specific increases in penile response to sexual but not other affective stimuli, demonstrating its specificity as a measure of genital response in men. To date, no study has used LDI to directly compare the genital response patterns of women and men. An advantage of LDI is that it is a direct measure of blood flow that can be applied to both women and men; however, like other measures of genital vasocongestion, gender/sex comparisons remain problematic given the anatomical and vascular differences of female and male genitalia.

Limitations of Measures of Genital Vasocongestion

A limitation of comparing direct or indirect indices of genital vasocongestion in women and men is that the arterial blood supply and circulatory system of the female and male genitalia differ. Branches of the internal iliac artery supply the majority of the pelvic structures in both sexes. One branch, the internal pudendal artery, is key to controlling the peripheral circulatory components of genital response (Graziottin & Gambini, 2015). The internal pudendal artery provides blood to the external genitalia in both sexes, but has a smaller lumen diameter, wall thickness, and wall-to-lumen ratio in women compared to men (Graziottin & Gambini, 2015). These discrepancies are related to differences in hemodynamic demand whereby the required blood volume and inflow pressures are much greater for the penis than the female external genitalia (the volume of blood required to fill the penis appears to be 10 times that required to fill the clitoral tissue during sexual response; Graziottin & Gambini, 2015; Kaufman et al., 1993; Maravilla & Yang, 2008). Changes in genital vasocongestion are, therefore, not necessarily

equivalent or comparable in women and men.

Even if a measure is highly sensitive to minute changes in genital vasocongestion, there is less capacity for variability in response magnitude for women compared to men, which may contribute to the observed gender/sex differences in genital response patterns. Furthermore, the vaginal canal is supplied by a branch of the internal iliac artery, called the vaginal artery (i.e., not the internal pudendal artery), which is thought to be homologous to the male inferior vesical artery that supplies the seminal vesicles and ejaculatory ducts (Mamatha, Hemalatha, Vinodini, Souza, & Suhani, 2012). This means that the VPP and PPG measure vascularization from different branches of the internal iliac artery, which could account for some of the discrepancies in the genital responding of women and men when measured with these instruments. A more valid test of whether or not the observed gender/sex differences in cue-specificity reflect real phenomena is to use the same measurement device at the same anatomical region in women and men.

Anal Photoplethysmography

Anal photoplethysmography can be used to directly compare the same physiological indicator of sexual response (vasocongestion) at the same anatomical site (intra-anally) for women and men. Direct comparisons of female and male data are appropriate with anal photoplethysmography because the device, its anatomical placement, and the data output are identical for both women and men. Researchers have commented on the advantages of anal photoplethysmography for assessing gender/sex differences in sexual response patterns and have noted that its presence in current sexual psychophysiological research is lacking (Chivers, 2017; Chivers, Suschinsky, et al., 2014; Janssen & Prause, 2016; Tavares et al., 2018). Furthermore, anatomical and vascular sex differences within the anus seem to be minimized, especially relative to the differences between female and male genitalia.

Anal Anatomy

The surgical anal canal is the most terminal part of the large intestine and lies below the rectum (specifically, the anorectal junction) and above the anal verge (i.e., anal opening). The anal canal is approximately 40 mm in length in both women and men (Bohlen & Held, 1979; Erden, 2018): 44 mm in men (range = 32–53 mm) and 49 mm in women (range = 30–50 mm; Nivatvongs, Stern, & Fryd, 1981). The anal canal is encircled by a number of muscles at different depths (Erden, 2018; Voorham-van der Zalm et al., 2013). The puborectalis muscle lies at the demarcation between the rectum and anal canal. The involuntary inner anal sphincter (IAS) represents the inner muscle layer that circles the anal canal and the voluntary external anal sphincter (EAS) complex is the outermost circular layer of the anal canal. Both the IAS and EAS are located at the most distal portion of the anal canal, below the puborectalis muscle, and control waste excretion.

In both women and men, the anal canal is supplied by the inferior rectal artery, which is a branch of the internal pudendal artery. In a recent study, Doppler endorectal ultrasonography was employed to examine resting state vascularization of the inner and outer structures of the anus in a non-clinical sample of women and men (Murad-Regadas et al., 2018). In both sexes, vascularization was greater for outer compared to inner structures, possibly reflecting the requirement of a larger blood supply to the relatively thicker external muscles. No sex differences in vascularization were observed within the outermost anal structures (i.e., the puborectalis and EAS); however, the inner structures (i.e., the IAS) had greater blood supply in men compared to women. The sex difference in vascularization of the inner anal structures was due to a wider range (higher upper end) of vascularity indices among men compared to women. These results suggest that sex differences in vascularization may be minimized, but not entirely eliminated, with anal assessment. It is also unknown whether these sex differences in resting

state vascularization reflect differences in anal vasocongestion during sexual arousal.

The extent to which gender/sex differences in the vascularization of the inner structures of the anus could differentially affect photoplethysmographic data is unknown, particularly given that the depth of light penetration of the photoplethysmograph is undetermined (C. Hakvoort, personal communication, February 16th, 2016). Some imaging techniques show that the thickness of the IAS and EAS is similar in women and men (e.g., Beets-Tan et al, 2001; Nielsen et al., 1992; Rociu, Stoker, Eijkemans, & Laméris, 2000). For instance, at the midlevel of the anal canal, the thickness of the IAS and EAS has been documented to be 1.6 mm and 7.3 mm, respectively, for men, and 1.6 mm and 7.2 mm, respectively, for women (Nielsen et al., 1992). Regadas et al. (2007) reported comparable thickness of the posterior IAS in women and men (0.18 versus 0.19 cm, respectively), but statistically significant sex differences in the thickness of the anterior (ventral) IAS (0.12 versus 0.19 cm, respectively). It is unknown whether the size of these differences in resting state muscle anatomy would hinder the comparability of anal photoplethysmography in women and men. Taken together, despite the limited sex differences in anal vascularity and muscularity during resting state, there are a number of similarities in female and male anal anatomy and physiology that make the anal canal an appropriate site to compare the sexual responses of women and men.

Traditional Anal Photoplethysmography

Bohlen and Held (1979) first documented the design and use of anal photoplethysmography to detect changes in anal vasocongestion in response to sexual stimulation (manual self-stimulation). Bohlen and Held postulated that changes in anal blood flow are a marker of sexual response based on Masters and Johnson's (1966) observation that changes in genital vasocongestion are a result of more generalized increases in blood volume throughout the pelvic region.

Bohlen and Held (1979) provided a comprehensive description of their anal photoplethysmograph design. The device contained a light-emitting diode (LED) photoplethysmograph to measure changes in vasocongestion and a pressure transducer to monitor muscle tension. The LED was encased in a thin-walled, compressible silicone tube that created an air-filled chamber. The pressure transducer was positioned at the base of the probe, in direct contact with the air chamber. A small needle gauge at the base of the device permitted air to be added to or drawn from the air chamber.

The anal probe was approximately 50 mm in length and its base was affixed to a small rubber anchor that rested against the anal verge (i.e., the transitional zone where the anal epithelium merges with the perianal skin). The rubber anchor was intended to reduce movement artifacts and to standardize device placement across participants. Bohlen and Held (1979) reported that the probe head was slightly bulbous to prevent expulsion and was located at the proximal boundary of the IAS and levator ani muscles (the puborectalis is part of the levator ani). The photoplethysmograph was located 17.5 mm from the anal verge and faced ventrally. Self-insertion was facilitated by use of a lubricant (petroleum jelly). According to Bohlen and Held, participants reported minimal discomfort inserting the device and that any discomfort subsided soon after placement. After the relaxation phase and during the sexual stimulation phase, participants often reported that they forgot that the device was inserted.

Bohlen and Held (1979) reported that they tested their anal photoplethysmograph with multiple participants, but data were presented (graphically) for only one man. Changes in blood volume and pulse amplitude, and muscle contraction were observed during orgasm induced via manual self-stimulation. There were no comparisons to a sexually non-aroused resting state. In two other studies, Bohlen and colleagues (Bohlen, Held, & Sanderson, 1980; Bohlen, Held, Sanderson, & Ahlgren, 1982) reported the concurrent assessment of anal vasocongestion and

muscular activity, but the latter was the exclusive focus of the studies.

Using small samples of women and men, Carmichael and colleagues (Carmichael, Warburton, Dixen, & Davidson, 1994; Carmichael et al., 1987) used an anal device that was equipped to concurrently detect changes in anal vasocongestion with an LED photoplethysmograph and changes in anal muscle activity with electromyography (EMG). Large increases in anal photoplethysmograph and anal EMG amplitudes coincided with orgasm, induced via manual self-stimulation. The figures presented in Carmichael et al. (1987, 1994) also show higher amplitudes during sexual stimulation prior to orgasm relative to resting state baseline, suggesting that anal photoplethysmography can be used to detect variation in sexual response. Carmichael and colleagues (1987, 1994) provided a limited description of their anal device, but with the information provided by Bohlen and Held (1979), these studies suggest that sexual response can be detected using anal photoplethysmography.

Only one study, Carmichael et al. (1994), has compared anal muscular and vascular activity in women and men during sexual stimulation. During baseline, muscle activity was similar, but vasocongestion was higher for women than men. During orgasm, both muscular and vascular activity were much higher for men than women. The authors did not statistically compare female and male responses during sexual stimulation prior to orgasm, but visual inspection of the figures shows similar linear increases in EMG and photoplethysmography amplitudes during sexual stimulation prior to orgasm. If similar increases in anal vasocongestion were recorded for women and men during sexual arousal (prior to orgasm), this suggests the potential applicability of anal photoplethysmography to the study of gender/sex differences in sexual response patterns.

As demonstrated by Carmichael and colleagues (1987, 1994), EMG can also be used to detect sexual response using the same methodology for women and men; however, more recent

evidence suggests that EMG is not specific to sexual stimulation and is sensitive to other emotional states, such as anxiety (e.g., Both & Laan, 2007; Both, van Lunsen, Weijenborg, & Laan, 2012; Hannan-Leith, Lalumière, Dayan, Hatfield, & Brotto, 2019). As such, EMG is not a suitable candidate to assess gender/sex differences in cue-specificity. Non-genital physiological changes, such as heart rate, respiration rate, and skin conductance, occur during sexual arousal and can be measured in the laboratory; however, these responses are also not specific to sexual stimulation and are indicators of autonomic arousal more generally (Laan et al., 1995; Zuckerman, 1971).

Intra-Anal VPP

The anal photoplethysmograph described by Bohlen and Held (1979) has many similarities to the VPP used in our laboratory (Technische Handelsonderneming Coos, Purmerend, The Netherlands). For instance, both are LED photoplethysmographs of similar size and length and involve an anchor to ensure a consistent and correct position and depth. Both photoplethysmographs render two signals simultaneously: the alternating current (AC) and the direct current (DC), thought to reflect pulse amplitude and blood volume, respectively (Bohlen & Held, 1979; Geer et al., 1974; Hatch, 1979; Heiman, 1977; Laan et al., 1995). It is, therefore, conceivable that the VPP could be applied intra-anally as an anal photoplethysmograph (hereafter referred to as an APG) to measure changes in vasocongestion associated with sexual arousal.

Current Study

Prior to testing cue-specificity with the APG, it is necessary to establish whether the VPP applied anally as an APG is a valid measure of sexual response. The specific aims of the current exploratory study were to: i) determine whether the APG can detect sexual responses induced via audiovisual sexual film clips; ii) examine whether responses detected with the APG are specific

to sexual stimuli; iii) assess the sensitivity of the APG to different degrees of sexual response elicited by stimuli that vary in sexual activity intensity; iv) examine the degree of correspondence between APG responses and self-reported sexual arousal; and v) test two photoplethysmograph orientations.

In order to test the sexual specificity of the APG (i.e., discriminative validity), nonsexual film clips that varied in intensity and valence (positive versus negative) were presented. Nonsexual stimuli were intended to elicit strong affective responses to account for the possibility that APG could be sensitive to physiological changes that occur during other heightened affective states (e.g., anxiety). If APG were a specific measure of sexual response, then we would expect increases in pulse amplitude in response only to sexual stimuli; responses to nonsexual stimuli that elicit affective responses (i.e., anxiety-provoking and exhilarating stimuli) should be comparable to neutral nonsexual stimuli (i.e., with minimal affective content).

To test the sensitivity of the APG to changes in sexual activity intensity, three types of female–male interactions were presented: nonsexual activity, low-intensity sexual activity (kissing and caressing), and high-intensity sexual activity (sexual intercourse). Consistent with past research (Suschinsky et al., 2009), we predicted that anal vasocongestion would be greater for sexual intercourse compared to stimuli exclusively showing kissing and caressing.

The association between anal pulse amplitude and self-reported sexual arousal (i.e., sexual concordance) was assessed because, traditionally, agreement between measures of sexual response is considered evidence of convergent validity (but see Chivers & Brotto, 2017, who challenge the assumption that genital and subjective responses should strongly align, particularly for women, and that low concordance is a sign of faulty measurement device). Consistent with measures of genital response (see meta-analysis by Chivers, Seto, Lalumière, Laan, & Grimbos 2010), we predicted that responses assessed with anal plethysmography would positively

correlate with self-reported sexual arousal.

Lastly, we tested two APG configurations—the LED and photodiode oriented ventrally (i.e., toward the perineum; orientation used in past research) or 90 degrees counter-clockwise (i.e., facing the participants' left side). The area to the left (or right) of the anal canal appears to be anatomically similar in women and men (Regadas et al., 2007; Voorham-van der Zalm et al., 2013), whereas organs located ventrally are sex-specific (e.g., prostate, vaginal canal). This investigation was exploratory in nature; therefore, no specific prediction was made.

Method

Participants

Participants were recruited via advertisements for a "sex research study" posted at a Canadian university. Sixty-seven women and 65 men responded to the advertisements and received detailed information about the study purpose and procedures. Participants were informed that the purpose of this study was to "investigate physiological sexual responses using a measurement device called an anal plethysmograph." Thirty-seven women and 29 men expressed interest and agreed to receive eligibility and screening information. The first 22 women and 22 men who were interested and eligible to participate were invited to schedule an appointment. All individuals who scheduled an appointment attended the experimental session. The data collection period spanned from October 2015 to June 2017.

The final sample of participants with usable data was 20 women (mean [*M*] age = 21.6, standard deviation [*SD*] = 3.2, range = 18–30) and 20 men (*M* age = 33.0, *SD* = 14.9, range = 19–75). Most participants had post-secondary education (women = 70%; men = 95%), were employed full-time, part-time, or casually (women = 60%; men = 50%), were in committed or dating relationships (women = 65%; men = 80%), had a current sexual partner (women = 80%; men = 90%), and self-identified as exclusively or mostly heterosexual (women = 85%; men =

95%). Based on responses to a questionnaire item adapted from the Kinsey scale (Kinsey, Pomeroy, & Martin, 1948; Kinsey, Pomeroy, Martin, & Gebhard, 1953), most participants were exclusively (women = 40%; men = 80%) or mostly (women = 45%; men = 20%) sexually attracted to the other sex. Three women (15%) reported equal sexual attraction to women and men. Eleven women (55%) reported using hormonal contraceptives at the time of testing and two women had missing data for this question. Of the seven women (35%) who were naturally cycling, three were in the luteal phase and four were in the follicular phase according to the reverse menstrual cycle day method outlined in Lamphrecht and Grummer-Strawn (1996). All women were nulliparous and premenopausal.

Eligibility

Eligible participants were fluent in English (to understand the instructions and complete the questionnaire), were 18 years of age or older, had experience using erotica for sexual purposes, and were cisgendered. We did not have an upper-age limit exclusion criterion. Individuals who were taking medications that can affect sexual functioning (e.g., antidepressants; Frolich & Meston, 2000; Serretti & Chiesa, 2009) or who had a sexually transmitted infection were not eligible to participate.

Recruitment posters and information emails specified that only mostly or exclusively heterosexual individuals were eligible. Inclusion of only heterosexual participants was important for selecting a uniform sexual stimulus set. In the questionnaire, however, some participants self-identified as bisexual (1 woman), reported that their current sex partners were both women and men (1 man), or reported equal sexual attraction to both women and men (3 women); these participants were retained for analysis because none reported more same-sex than other-sex sexual attraction; as such, the female–male sexual stimuli were expected to be sexually arousing for these participants.

Only participants who had previous experience with anal insertion were eligible. The eligibility criteria specified that anal insertion could have occurred during medical examination or during partnered or solitary sexual activity with a finger, penis, sex toy, or another object. The purpose of this criterion was to mitigate participant discomfort. Individuals were not eligible if they were seeking treatment or using medications for symptoms of pelvic organ prolapse, lower urinary tract symptoms, bowel symptoms or pain, and/or sexual difficulties related to pelvic floor dysfunction (Murad-Regadas et al., 2018). Example of disqualifying conditions included inflammatory bowel disease (i.e., Crohn's disease or ulcerative colitis), anal or anal sphincter surgery, hemorrhoids, severe constipation, or fecal incontinence.

Sample Size Determination

The target sample size of 22 men and 22 women was determined based on a power analysis using VPP data. VPA *M* and *SD* for the female–male intercourse and the nonsexual stimulus categories in Sawatsky et al. (2018) were used in the Borenstein et al. (2006) formula for calculating effect sizes between pairs of data. The Borenstein et al. formula computes a Hedge's *g* effect size and its 95% confidence interval (CI) based on the standard error of *g* and critical *t* values. Hedge's *g* is a corrected form of Cohen *d* that is considered more appropriate for relatively small samples. The sample size value in the Borenstein et al. formula was systematically decreased to determine the necessary number of participants to detect a difference in VPA between the female–male intercourse and nonsexual categories with the lower bound of the 95% CI remaining above 0.20. According to this analysis, a minimum sample of nine was necessary. Replicating this calculation with VPP data from another study in our laboratory (Dawson et al., 2015) confirmed this sample size estimate.

Given that the APG had not yet been used in prior research and because we sought to detect differences across a number of stimulus categories, we decided to recruit 22 men and 22

women, which we anticipated would result in a final sample of 20 participants of each gender/sex with usable data. Sexual psychophysiological studies report 15% (e.g., Dawson et al., 2015; Suschinsky et al., 2009) to 30% (Huberman & Chivers, 2015) data loss for several reasons, including uncorrectable artifacts in VPP data or software malfunctions that affect data collection. A usable sample size of approximately 20 is consistent with other research studies in our laboratory (e.g., Sawatsky et al., 2018).

Apparatus and Materials

Experimental Stimuli

The experimental stimuli comprised 12, 90-s audiovisual film clips from six stimulus categories, with two exemplars per category: neutral (scenes from nature documentaries); anxiety (woman being chased by a rabid dog, woman being chased through a forest); exhilarating (first-person view of a roller-coaster ride, woman competing in a surf competition); female–male nonsexual interaction (ballet duet, couple performing acro-yoga); female–male low-intensity sexual activity (partially clothed couple kissing and caressing); female–male high-intensity sexual activity (nude couple engaging in penile-vaginal penetration). With the exception of the neutral and nonsexual interaction stimuli, all film clips were from the Suschinsky et al. (2009) VPP validation study. The original background music from the sexual films was updated based on pilot-participant feedback that the original music was outdated and distracting. The background music for the sexual films and the nonsexual interaction films did not include song lyrics and there were no sexual vocalizations. The male-narrated neutral films have been used in a number of studies in our laboratory (e.g., Dawson, Sawatsky, & Lalumière, 2015; Sawatsky, Dawson, & Lalumière, 2018; Sawatsky & Lalumière, 2020) and consistently do not elicit a sexual response. The nonsexual interaction films were used in Sawatsky and Lalumière (2020) and did not elicit self-reported sexual arousal or genital response. Film clips of 60–120 s per

stimulus category are common in VPP studies (e.g., Bossio et al., 2014; Chivers et al., 2004, 2007; Sawatsky et al., 2018; Suschinsky et al., 2009) and recent research has demonstrated that 60–90-s audiovisual sexual stimuli are of sufficient duration to generate self-reported sexual arousal and to capture maximum genital vasocongestion assessed with VPP (Sawatsky et al., 2020).

Three types of female–male interactions were presented to test the sensitivity of the APG to differences in sexual stimulus intensity. Suschinsky et al. (2009) observed a sexual activity intensity effect, such that the high-intensity sexual stimuli elicited greater VPA than the low-intensity sexual stimuli. The purpose of including a nonsexual female–male interaction category was to present films with comparable elements to the sexual stimuli (e.g., physical touch and body movement) without overt sexual cues.

The exhilarating and anxiety-provoking stimulus categories were intended to elicit strong affective responses (relative to the neutral stimulus) that were positively and negatively valenced, respectively. Inclusion of the exhilarating and anxiety categories was to test the specificity of APG as a measure of sexual response, rather than of heightened affective states more generally. Overall, Suschinsky et al. (2009) found that these films evoked the intended affective responses; however, women rated the anxiety-provoking stimuli as more intense than the exhilarating and high-intensity sexual stimuli.

At the onset of the experiment, a still image of a neutral nature scene (a beach) was presented for 180 s as an adaptation stimulus. Following the adaptation stimulus, a neutral baseline stimulus (waves crashing into a beach) was presented for 90 s, followed by the experimental stimuli. The experimental stimuli were presented in two blocks, with each block containing one film from each of the six stimulus categories. Stimuli were randomized within each block and presented so that films from the same stimulus category were separated by at

least one other stimulus. All stimuli were presented on a 52 cm computer monitor situated at eye-level approximately 150 cm from the participant. The audio component of the films was presented through noise-cancelling headphones worn by the participants.

Physiological Sexual Response

The APG was nearly identical to the VPP used in our laboratory and was made by the same manufacturer (Technische Handelsonderneming Coos, Purmerend, The Netherlands). The APG involved a tampon-shaped acrylic probe that contained a photodiode light detector and an orange-red spectrum LED light source. The photodiode and LED were located approximately 30 mm and 40 mm, respectively, from the top of the silicone anchor (or from the anal verge when the probe was inserted). Like the VPP, the APG yielded two signals: the direct current (DC) and the alternating current (AC). The DC is considered an index of the total blood volume and the AC is thought to represent the phasic changes in vasocongestion in the vascular walls that result from pressure changes within the blood vessel associated with each heartbeat (larger amplitudes reflect greater vasocongestion; Hatch, 1979; Janssen, 2002; Laan et al., 1995). In VPP studies, the AC signal is commonly referred to as VPA and has been found to be superior in sensitivity and specificity compared to the DC signal (e.g., Geer et al., 1974; Heiman, 1977; Laan et al., 1995; Osborne & Pollack, 1977). For this reason, the AC signal was used to record anal responses in this study, hereafter referred to as anal pulse amplitude (APA).

Like with VPP, the APG data were recorded continuously throughout each stimulus at a rate of 10 samples/s, band-pass filtered (0.5–10 Hz) and digitized (40 Hz) using Limestone Technologies Inc. (Odessa, ON, Canada) DataPac_USB and Preftest software, Version 10. A silicone anchor was attached to the cable of the APG to ensure that the light source and light detector remained inserted to a correct and consistent depth and orientation. The LED and photodiode were oriented ventrally (i.e., facing the front toward the perineum) for half of the

participants; for the other half, it was oriented 90 degrees counter-clockwise (i.e., facing participants' left side). The orientation of the probe was set by the experimenter prior to the session. The silicone anchor of the APG was smaller in length and width compared to that of the VPP in order to accommodate its alternate placement against the anal verge instead of against the labia. The APG was self-inserted by the participants. During pilot-testing, participants reported minimal discomfort and considered self-insertion more acceptable than insertion by a healthcare professional.

A SKYN® condom covered the APG at all times (see Figure 5.1). The purpose of the disposable condom cover was to increase participant safety and comfort by ensuring that the device was never in direct contact with the participant. The condom was affixed to the APG by the experimenter immediately prior to the session. The condom covered the APG probe, rubber anchor, and several inches of the cord, and was affixed using small medical-grade elastic bands that were secured above and below the rubber anchor. SKYN® condoms are polyisoprene (synthetic latex) and are a suitable choice for people with latex allergies. Participants were also provided with Wet Plantinum® silicone-based personal lubricant to facilitate insertion. Both SKYN® condoms and Wet Platinum® have been used in other sex research studies (Herbenick et al., 2011; Sawatsky & Lalumière, 2020). Sawatsky and Lalumière (2020) demonstrated that VPP data collection and signal quality were not jeopardized when a SKYN® condom was used to cover the VPP probe. In a study examining the impact of personal lubricants on epithelial cell lines and colorectal explant tissues, Wet Platinum® was found to be non-toxic and one of the two safest lubricants of the 14 types tested (Dezzutti et al., 2012). After each testing session, the APG underwent a prewash with sodium lauryl sulphate soap and was subjected to a high-level disinfection protocol involving Cidex® OPA (ortho-phthalaldehyde; Prause & Janssen, 2005).

Self-Reported Sexual Arousal

Self-reported sexual arousal was assessed continuously during each stimulus presentation. Participants were instructed to press the "+" key on a keypad whenever they felt an increase in sexual arousal and the "-" key whenever they felt a decrease in sexual arousal. Pressing the appropriate key on the keypad corresponded to the increase or decrease of a green bar on the side of the computer monitor that ranged from 0 (no sexual arousal) to 100 (maximum degree of sexual arousal, similar to that experienced before orgasm). Prior to the beginning of each stimulus, participants were instructed to move the green bar to their current level of sexual arousal to establish the trial baseline. Participants were also asked to rate their sexual arousal on a 9-point Likert scale before (pre-stimulus) and after (post-stimulus) each stimulus presentation ("*How sexually aroused do you feel?*"), where 1 was no sexual arousal and 9 was maximum sexual arousal (akin to arousal at orgasm).

*Post-Stimulus Question***s**

Following the post-stimulus sexual arousal question, participants were asked to rate how pleasant, unpleasant, intense, exhilarating, anxiety-provoking, and erotic the film was (e.g., "*How anxiety-provoking was the film?*") on a scale from 1 (not at all) to 9 (extremely) in order to determine the degree to which the films elicited the intended affect. The experimenter provided a definition of each affective term during the experimental procedure explanation with the aim to improve construct validity. All questions were presented in a fixed order on the computer monitor (the software did not allow for randomization) and participants used the keypad to make their ratings.

Questionnaires

Participants completed a standard questionnaire package used in our laboratory that includes questions related to biographical information, sexual history, and sexual interests.

Participants' sexual attraction was assessed using a question adapted from the Kinsey scale (Kinsey et al., 1948; Kinsey et al., 1953). Participants rated their sexual attraction on a 7-point scale where 0 reflected exclusive other-sex sexual attraction, 3 reflected equal sexual attraction to women and men, and 7 reflected exclusive same-sex sexual attraction. The final section of the questionnaire elicited feedback about the experiment and the APG device. Questionnaire items inquired about overall comfort, ease of use of device and associated procedures, and quality of sexual stimuli. The degree to which the APG was uncomfortable was rated on a 5-point scale with the following anchors: not at all, a little bit, somewhat, definitely, extremely. In an open-ended format, participants were asked to provide additional feedback about the APG device (e.g., ease of insertion, use of lubricant), films, and overall experience. The questionnaire was accessed online via the survey host Qualtrics and was completed using a secure tablet.

Procedure

Prospective participants could respond to posted advertisements via telephone or e-mail and received information about the experimental procedure and eligibility criteria. Prospective participants were provided the option to visit the laboratory to familiarize themselves with the APG and the testing environment prior to making a decision regarding participation (one woman requested a laboratory visit and she subsequently decided to participate). Prospective participants were also invited to request a sample of the hypoallergenic latex-free condom and the silicone-based lubrication prior to the experiment to determine whether the materials irritated their skin (no one made this request).

Participants were instructed to refrain from sexual activity for 24 hours prior to the scheduled experimental session and all forms of physical exercise for the one hour prior (Meston & Gorzalka, 1996). Participants were also asked to refrain from using alcohol, tobacco, cold medications, and recreational drugs on the day of testing. Women's appointments were

scheduled on non-menstruation days. Questionnaire responses confirmed that most participants complied with the pre-session instructions, with the exception that three men reported smoking nicotine on the day of testing.

Participants were assessed individually by one of three female experimenters. After the experimenter provided an explanation of the experimental procedure, including verbal and written instructions on how to insert the APG, participants were given the opportunity to read and sign the consent form. Once the experimenter left the room, participants undressed from the waist down and followed the written step-by-step, written instructions detailing how to correctly insert the APG device. Participants were instructed to wear latex-free gloves and to place a dime-sized amount of personal lubricant on the APG probe. Next, they were instructed to stand with one leg on a footstool, bend slightly at the waist, and use one hand to separate the buttocks while the other hand gently but firmly inserted the APG probe until the silicone anchor rested against the anal verge. Following insertion, participants were asked to stand with their feet together and to clench their buttocks for a few moments. These instructions are adapted from those provided with over-the-counter anal suppositories. Participants were instructed to use a self-standing mirror to facilitate insertion.

Once the APG was in place, participants were instructed to carefully and gently sit in the reclining chair. A memory-foam coccyx seat cushion was provided to reduce pressure on the APG. Once seated, participants were asked to check that the APG had remained inserted to the correct depth, such that the silicone anchor rested against the anal verge. If the APG were extruded at any time during the experiment, participants were instructed to inform the experimenter and to gently re-insert the device to the correct depth (no participants reported APG extrusion). Once comfortably seated with the APG and headphones in place, participants informed the experimenter that they were ready to begin the experiment.

Most communication from the experimenter was via text messages that appeared on the participant screen. A hands-free intercom system was also available and facilitated communication from the participant. If during the experiment there was a substantial change in the overall waveform, participants were asked between films (using a text message) to check that the probe was fully inserted; this occurred for three women and no men, and none reported probe extrusion.

Participants were first presented with the 180 s adaptation stimulus. The purpose of the adaptation stimulus was to allow participants to become accustomed to the APG and the experimental setting. The adaptation stimulus was followed by the 90 s baseline stimulus, used to establish the participants' baseline level of responding (session baseline). The physiological responses to the adaptation and baseline trials were not used in the analyses. Next, participants were presented with the experimental stimuli. Participants were instructed to respond to the stimuli as naturally as possible and to avoid movement (e.g., muscles contractions, genital touching, coughing, talking) during the film presentations (the APG is highly sensitive to movement and even slight voluntary or involuntary movements can produce artifacts in photoplethysmography data). Participants were asked to continuously rate their self-reported arousal during the baseline stimulus and all experimental trials.

All stimuli were separated by a 120 s interstimulus interval. Immediately after each stimulus presentation, participants used the keypad to rate their post-stimulus sexual arousal and degree to which the film was erotic, intense, pleasant, unpleasant, exhilarating, and anxiety-provoking. After submitting their ratings, participants were instructed to sit comfortably until the next trial commenced. The experimenter started the next trial when the APA decreased to baseline levels (established during the session baseline) and was maintained at this level for 5 s. If APA did not return to baseline within 120 s, participants were provided a distraction task in

which they were asked to count backwards from 100 in different multiples (see Suschinsky et al., 2009). Instructions were presented on the computer monitor (e.g., “Please count out loud, backwards from 100, in multiples of 5”). Once APA returned to baseline or after a maximum of 180 s, the pre-stimulus sexual arousal question appeared on the computer monitor (indicating to the participant to cease counting). This question was presented after 180 s of counting, regardless of whether or not physiological sexual response returned to baseline (i.e., the maximum length of the interstimulus interval was 300 s). After answering the pre-stimulus sexual arousal question, participants were asked to move the green bar to correspond with their current level of sexual arousal. Once the green bar was stable, the next film commenced.

After all experimental stimuli were presented, participants were asked to redress, place the APG in a sealable plastic bag, and complete the questionnaire. Upon completion of the questionnaire, the experimenter debriefed the participant about the purpose of the study and provided the $60 CDN compensation. The entire study was approximately two hours in length. The university’s Research Ethics and Integrity Board reviewed and approved all experimental procedures in accordance with the ethical guidelines of the Canadian Tri-Council Policy Statement.

Analysis

Artifact Removal

Two of the experimenters, masked to experimental conditions, independently identified and removed artifacts in the APG data using a two-step process. APA waveforms were visually inspected and large, obvious artifacts (i.e., sudden, drastic changes in amplitude) were detected and manually removed in PrefTest in 1 s intervals. Data were exported to Excel and data points that were more than ± 3 *SD* from the mean of a given trial were identified and then manually removed in PrefTest. The average number of edited artifacts per participant with valid data for

the 12 experimental trials (total stimulus time = 1260 s) for women was 20.3 s (*SD* = 16.2, median = 15.5, range = 3–64) or 1.6% of the total stimulus time, and for men was 17.8 s (*SD* = 11.0, median = 16.5, range= 1–57) or 1.4%. These values were higher than for VPP studies in our laboratory. Sawatsky and Lalumière (2020) reported an average of 3.68 s (*SD* =5.86, median = 1.00 s) of edited artifacts or 0.4% when using 14, 60-s stimuli (total stimulus time = 840 s).

Waveform Evaluation

For many participants, the APG waveform morphology was uncharacteristic compared to that observed with VPP. VPP waves have fairly smooth periodic oscillations, and amplitudes that gradually increase or decrease with corresponding changes in sexual response (see bottom rows of Figures 5.2 and 5.3). For many participants, the curvature or transition between the extrema (i.e., crests and troughs) of the APG waves were sharp and jagged, and the extrema varied irregularly and asymmetrically around the midline of the wave. Some trials were marked by sudden spikes in amplitude that occurred regularly during the trial; due to their regularity, they were not considered artifacts and they were not identified as such using our data cleaning procedure (i.e., the spikes were not ± 3 *SD* from the mean). Some waveforms were complex and contained a mixture of wave shapes involving arches (one extremum sharper than the opposite) and sawtooths (a fast rise and a slow linear decay, or vice versa). For three male participants, waveforms were VPP-typical, but the overall pattern of amplitude change across the stimulus duration was unusual in that it appeared wave-like, with gradual and repetitive increases and decreases in amplitude that did not correspond with self-reported sexual arousal (see Figure 5.4).

In light of these atypical features, each participant's waveform morphology was qualitatively evaluated based on visual appearance by two of the experimenters and classified using a three-point scale: poor (9 women, 4 men), adequate (9 women, 10 men), or good (4 women, 8 men). Ratings were based on what is considered a typical waveform for VPA.

Waveforms were generally consistent within-subjects and did not improve with increased sexual arousal. When the quality of the wave shape varied by trial (1 women, 3 men), waveforms were rated as adequate. Evaluators agreed on 88.6% of participants; any discrepancies were discussed and a mutual agreement was made. Figures 5.2 and 5.3 present examples of APG data rated as poor, adequate, or good for the first 40 s of a neutral and a high-intensity sexual stimulus. All data were retained for the main analyses because the intra-anal application of the VPP is novel and so it is unknown what constitutes typical APG waveform morphology.

Data Exclusion

The data from two men and two women were excluded from the analyses. It was determined during the verbal debriefing that two men had participated twice in the study; therefore, data from their second session were excluded. Data for one woman whose signal morphology was rated as poor and characterized by repeated, uncorrectable artifacts was excluded from the analyses. Data from another woman was excluded due a substantial number of movement artifacts (>20 s of missing data per trial) in both exemplars of the exhilarating category, which prevented the calculation of mean APA for that stimulus category; APA morphology was evaluated to be poor across most trials for this participant. If only one exemplar of a stimulus category had >20 s of missing data, the trial was excluded and for the affected stimulus category was based on the valid exemplar only; this occurred for two women (two trials each).

Data Preparation

It is common in VPP studies (e.g., Chivers et al., 2007; Suschinsky et al., 2009) to present VPA change scores, computed by subtracting the trial baseline (the level of response immediately before the trial onset) from the mean response for that trial (i.e., mean-minus-baseline; MMB). Due to the high number of artifacts, and the irregular and sporadic spikes in

amplitude for many of the APG participants, it was difficult to initially establish a session baseline and to maintain a consistent baseline for 5 s prior to commencing each trial. Due to the unreliability of the baselines, analyses were performed using mean APA. The mean APA values of the two exemplars of a stimulus category were averaged to produce a mean score for each stimulus category. The within-subjects correlation between mean APA and MMB APA across all six stimulus categories for women was r = .35, 95% CI [.01, .61]; this association is weaker compared to VPP studies in our laboratory (e.g., Sawatsky et al., 2018, reported r = 0.57 [0.33, 0.74]). For men, the within-subjects correlation between mean APA and MMB APA across all six stimulus categories was r = .64 [.35, .82].

Change scores were also calculated for continuous sexual arousal by subtracting the trial baseline from the mean continuous self-reported sexual arousal for that trial (MMB). Pre- and post-stimulus sexual arousal rating change scores were also computed for each trial. MMB scores were averaged across both exemplars to produce a mean change score for each stimulus category. The continuous and the pre/post sexual arousal ratings produced similar results; as such, we present only mean change in continuous self-reported sexual arousal. According to Huberman et al. (2013), self-reported sexual arousal change scores are less susceptible to impression management biases than post-stimulus responses alone.

Analysis

To verify that the stimulus categories elicited the intended self-reported responses, within-subjects analyses of variance (ANOVAs) were conducted with stimulus category as the independent variable (IV) and self-reported affective and sexual arousal ratings as the dependent variables (DV). To examine physiological response, a series of mixed ANOVAs were performed with APA as the DV. For each ANOVA, the F-statistic and the partial eta-squared (η_p^2) effect size with the 90% CI are presented. The 90% CI is most appropriate for one-sided statistics that

do not have negative values (Lakens, 2013). The η_p^2 CI was computed using the Smithson script (Smithson, 2001; Smithson, n.d.). When the assumption of sphericity was violated, a Greenhouse-Geisser correction was applied.

Outliers were defined as values greater than 2.58 *SD* from the mean (Tabachnick & Fidell, 2007). Seven outliers were identified for self-reported sexual arousal across all participants, with no more than two outliers per trial; outliers were retained because their exclusion did not affect the pattern of results. For APG responses, outliers were identified separately for women and men because men's APA values were higher on average compared to women. Two outliers were identified for women; excluding these outliers did not affect the pattern of results. For men, one outlier was identified for each stimulus category, representing data for one male with particularly high APA (range 40.17–52.1 mV). Data for this man were considered sufficiently connected with the rest of the dataset because other participants provided intervening values (range of 20–30 mV; Tabachnick & Fidell, 2007). The same pattern of APA results was observed when this man's data was excluded from analyses.

To assess for the impact of outliers on the normality of the data, skewness and kurtosis were examined for APA data. Male data exhibited positive skewness and kurtosis; skewness and kurtosis were not problematic for women. For men, there was a large range of APA scores, both within- and between-subject, relative to women. Some men produced APA in the range observed for women (and that is typical for VPP), whereas other men produced much higher APA. Male APA ranged from 0.44–55.0 mV across all trials, whereas women's ranged from 0.60–11.29. Within-subjects difference scores between participants' highest and lowest APA value across all trials ranged from 1.04–55.00 mV for men, and 0.95–7.93 mV for women. Despite the skewness and kurtosis in the male data (and the male outlier), data were not transformed in order to maintain the original scale of the DV.

For pairwise comparisons, we present the effect size of the difference in response between the two stimulus categories compared. We computed Hedge's *g* effect sizes and the 95% CI using the method outlined by Borenstein et al. (2006). Hedge's *g* can be interpreted the same as Cohen's *d*. For *g*, the 95% CI is appropriate because *g* can have both positive and negative values. On the figures, the error bars represent the 95% CI of the data point and were calculated using the method outlined by O'Brien and Cousineau (2014).

The concordance between physiological and self-reported sexual arousal was calculated using within-subjects correlations to allow for comparison with other studies (e.g., meta-analysis by Chivers et al., 2010). A Pearson correlation coefficient (*r*) was computed for each participant by correlating mean APA and MMB self-reported sexual arousal across stimulus categories. The *r* coefficients were z-transformed and the mean of the z-transformed coefficients was computed. After the 95% CI was calculated around the mean z-transformed coefficient, the coefficient and its 95% CI were transformed back to *r*.

Results

Stimulus Category Manipulations

Affective Responses

Ratings on the self-report measures (DV) served as a manipulation check. Ratings for the post-stimulus affect questions were combined for women and men because ANOVAs revealed no interactions between participant gender/sex and stimulus category. The means and *SD*s of the post-stimulus affect and sexual arousal ratings across all stimulus categories are presented in Table 5.1.

To determine whether affective stimulus categories elicited the intended response, self-reported affect ratings were subjected to a 3 (Stimulus Category: Neutral, Exhilarating, Anxiety) X 4 (Affect Question: Pleasant, Unpleasant, Exhilarating, Anxiety-Provoking) within-subjects

ANOVA. There were main effects of Stimulus Category, $F(2, 78) = 39.40$, $\eta_p^2 = 0.50$, 90% CI [0.36, 0.59], and Affect Question, $F(2.44, 95.21) = 21.57$, $\eta_p^2 = 0.36$ [0.22, 0.45], and an interaction, $F(3.56, 138.76) = 91.10$, $\eta_p^2 = 0.70$ [0.63, 0.74]. Planned comparisons showed that the Anxiety category was rated as more anxiety-provoking, $g = 1.28$, 95% CI [0.90, 1.71], and more unpleasant, $g = 2.18$ [1.52, 2.92], than the Exhilarating category. The Exhilarating category did not elicit more self-reported exhilaration than the Anxiety category, $g = 0.13$ [–0.18, 0.45], but it was rated as more pleasant, $g = 1.75$ [1.19, 2.37]. Compared to Neutral, the Anxiety and Exhilarating categories were rated as more anxiety-provoking ($g = 2.01$ [1.33, 2.77] and $g = 0.78$ [0.30, 1.30], respectively) and more exhilarating ($g = 1.12$ [0.59, 1.69] and $g = 1.22$ [0.81, 1.67], respectively). The Anxiety and Exhilarating categories were also rated as less pleasant ($g = –2.18$ [–2.93, –1.52] and $g = –0.52$ [–0.84, –0.23], respectively) and more unpleasant ($g = 2.20$ [1.53, 2.96] and $g = 0.51$ [0.09, 0.95], respectively) than Neutral. Taken together, the Anxiety and Exhilarating stimulus categories elicited affective responses and responses differed from each other in terms of negative and positive valence.

Stimulus Intensity

Post-stimulus intensity ratings were compared across all six stimulus categories. There was a main effect of Stimulus Category on intensity ratings, $F(3.95, 154.01) = 45.14$, $\eta_p^2 = 0.54$, 90% CI [0.44, 0.60]. The Anxiety category was rated as more intense compared to all stimulus categories, including the Neutral, $g = 2.15$, 95% [1.56, 2.82], Exhilarating, $g = 0.81$ [0.57, 1.08], and High-Intensity Sexual, $g = 1.03$ [0.63, 1.48], categories.

The High-Intensity Sexual category was rated as more intense than the Low-Intensity Sexual category, $g = 0.28$, 95% CI [0.02, 0.54], but similar in intensity to the Nonsexual Interaction, $g = 0.14$ [–0.17, 0.46]; therefore, we did not find the expected linear increase in self-reported intensity ratings as a function of increasing sexual content for female–male categories,

$F(1, 39) = 0.74$, $\eta_p^2 = 0.02$, 90% CI [0.00, 0.13], and instead a quadratic trend was observed, $F(1, 39) = 12.37$, $\eta_p^2 = 0.24$ [0.07, 0.40]. A post-hoc within-subjects ANOVA with erotic ratings as the DV showed a linear trend, $F(1, 39) = 77.83$, $\eta_p^2 = 0.67$ [0.50, 0.75], and no quadratic trend: The High-Intensity Sexual category was rated as more erotic than the Low-Intensity Sexual category, which in turn was rated as more erotic than the Nonsexual Interaction category. Another post-hoc within-subjects ANOVA with pre/post sexual arousal change scores showed a linear trend, $F(1, 39) = 77.40$, $\eta_p^2 = 0.66$ [0.50, 0.75], and no quadratic trend, with the High-Intensity Sexual category rated as the most sexually arousing and the Nonsexual Interaction category as the least sexually arousing. Thus, the High-Intensity Sexual category was rated as more intense, more erotic, and more sexually arousing than the Low-Intensity Sexual category, as expected. Although the Nonsexual Interaction category was similar to the High-Intensity Sexual category in terms of general intensity, it was less erotic and less sexually arousing than the High- and Low-Intensity Sexual categories.

Continuous Self-Reported Sexual Arousal

Continuous self-reported sexual arousal data was not recorded for one man; therefore, analyses are based on 39 participants. A within-subjects ANOVA with all six stimulus categories showed a main effect of stimulus category on continuous self-reported sexual arousal, $F(1.92, 70.98) = 60.73$, $\eta_p^2 = 0.62$, 90% CI [0.49, 0.69]. Similar to the post-stimulus affect ratings, there was no effect of participant sex, $F(1, 37) = 0.11$, $\eta_p^2 = 0.00$ [0.00, 0.11]. Figure 5.5 shows that for both women and men, only female–male stimuli (nonsexual interaction, low-intensity sexual, high-intensity sexual) elicited increases in continuous self-reported sexual arousal. Planned comparisons, collapsing across participant sex, showed that the High-Intensity Sexual category elicited greater sexual arousal than the Low-Intensity Sexual category, $g = 0.90$, 95% CI [0.68, 1.18], which in turn elicited greater sexual arousal than the Nonsexual Interaction, $g = 0.72$

[0.36, 1.10]. The Nonsexual Interaction elicited greater sexual arousal than the Neutral, g = 1.28 [0.64, 1.96], Exhilarating, g = 0.80 [0.29, 1.33], and Anxiety, g = 1.17 [0.62, 1.77], categories.

Physiological Sexual Response

A 2 (Sex: Male, Female) X 2 (Probe Orientation: Left, Ventral) X 6 (Stimulus Category: Neutral, Exhilarating, Anxiety, Nonsexual Interaction, Low-Intensity Sex, High-Intensity Sex) mixed ANOVA revealed a three-way interaction on mean APA, $F(2.22, 79.97) = 4.92$, $\eta_p^2 = 0.12$ [0.02, 0.22], and a main effect of Sex, $F(1, 36) = 6.33$, $\eta_p^2 = 0.15$ [0.02, 0.32]. The effect sizes of all other main effects and interactions were $\eta_p^2 < 0.07$ with CI that included zero. Means and *SD* of the 24 cells are presented in Table 2 and means and 95% CI are plotted in Figure 5.6. To examine the main effect of Stimulus Category and the interaction between Stimulus Category and Probe Orientation, simple main effects were conducted separately for women and men.

Women

Women showed a main effect of Stimulus Category, $F(2.40, 43.21) = 9.45$, $\eta_p^2 = 0.34$, 90% CI [0.13, 0.47], no main effect of Probe Orientation, $F(1, 18) = 2.54$, $\eta_p^2 = 0.12$ [0.00, 0.35], and no interaction between Stimulus Category and Probe Orientation, $F(2.40, 43.21) = 1.73$, $\eta_p^2 = 0.09$ [0.00, 0.20]. Collapsing across Probe Orientation, planned comparisons showed that the High-Intensity Sexual category elicited greater APA compared to all other stimulus categories: Neutral, g = 0.48, 95% CI [0.11, 0.89]; Exhilarating, g = 0.62 [0.31, 0.99]; Anxiety, g = 0.49 [0.18, 0.83]; Nonsexual Interaction, g = 0.50 [0.19, 0.85]; Low-Intensity Sexual, g = 0.25 [0.02, 0.51]. The Low-Intensity Sexual category elicited greater APA than the Nonsexual Interaction, g = 0.23 [0.05, 0.43]. The APG did not detect a response to nonsexual affective categories: APA for the Neutral category was higher than or similar to the Exhilarating, g = 0.21

[0.02, 0.41], and Anxiety, g = 0.02 [–0.22, 0.27], categories.[1] For 75% of women, the highest mean APA value was demonstrated in response to a sexual stimulus category, with 60% of women responding the most to the High-Intensity Sexual category and 15% responding the most to the Low-Intensity Sexual category.

Men

For men, there was no main effect of Stimulus Category, $F(2.16, 38.83) = 0.86$, $\eta_p^2 = 0.05$, 90% CI [0.00, 0.47], and no main effect of Probe Orientation, $F(1, 18) = 0.01$, $\eta_p^2 = 0.00$ [0.00, 0.02], but there was an interaction between Stimulus Category and Probe Orientation, $F(2.16, 38.83) = 3.91$, $\eta_p^2 = 0.18$ [0.01, 0.32].[2] To follow-up on the interaction, APA was examined across stimulus categories separately for men with the ventral and left probe orientations.[3] As shown in Figure 5.6, an increase in APA was observed in response to the High-Intensity Sexual category only for the Ventral orientation. For the Ventral orientation, APA was greater for the High-Intensity Sexual category compared to the Neutral, g = 0.22 [0.04, 0.44], and Nonsexual Interaction, g = 0.18 [0.03, 0.36], categories. APA also increased for the High-Intensity Sexual category relative to the Exhilarating and Anxiety categories, but the CI crossed zero: g = 0.23 [–0.02, 0.53], and, g = 0.18 [–0.03, 0.43], respectively. APA did not distinguish between the High- and Low-Intensity Sexual categories, g = 0.09 [–0.13, 0.33]. APA to the Low-

[1] A similar pattern of results was found when these analyses were performed with MMB for women: The High-Intensity Sexual stimulus elicited greater MMB APA than all four nonsexual stimulus categories, but there was less discrimination between the High- and Low-Intensity Sexual categories, and between the Low-Intensity Sexual and Nonsexual Interaction categories.

[2] Given the large age range for men, age was included as a covariate in an additional ANOVA; controlling for age did not change the pattern of results. The overall pattern of results was also similar for men's MMB APA, but the effect size of the interaction between Stimulus Category and Probe Orientation decreased to $\eta_p^2 = 0.12$, 90% CI [0.00, 0.23].

[3] A subsidiary analysis showed that continuous self-reported sexual arousal did not vary by probe orientation in men, ruling out the possibility that differences in APA patterns for the left and ventral probe orientations were related to differences in the felt experience of sexual arousal between probe orientation conditions.

Intensity Sexual category was comparable to the Nonsexual Interaction, g = 0.06 [–0.05, 0.17], and Neutral, g = 0.05 [–0.01, 0.12]. The Exhilarating and Anxiety categories did not elicit an increase in APA relative to Neutral: g = 0.01 [–0.09, 0.11], and g = 0.02 [–0.03, 0.07], respectively. For the Ventral probe orientation, 80% of men produced the highest mean APA to a sexual stimulus category, with 50% responding most to the High-Intensity Sexual category and 30% responding the most to the Low-Intensity Sexual category.

For the Left orientation, APA appeared to decrease in response to sexual stimulation, although all pairwise comparisons produced effect sizes with CI that included zero. For instance, the High-Intensity Sexual Stimulus appeared to elicit lower APA than all categories with nonsexual content, but the CI were large and included zero: Neutral, g = –0.12, 95% CI [–0.60, 0.33]; Exhilarating, g = –0.14 [–0.67, 0.35]; Anxiety, g = –0.17 [–0.58, 0.20]; Nonsexual Interaction, g = –0.04 [–0.38, 0.30]. APA was comparable for the High- and Low-Intensity Sexual categories, g = 0.09 [–0.13, 0.33]. APA was also similar for the Exhilarating, g = 0.02 [–0.07, 0.11], and Anxiety, g = 0.05 [–0.03, 0.15], categories compared to Neutral. For the left probe orientation, 50% of men produced the highest mean APA to a sexual stimulus category, with 40% responding most to the High-Intensity Sexual category and 10% responding the most to the Low-Intensity Sexual category.

Signal Quality

A within-subjects ANOVA was performed on mean APA for only those participants whose signal morphology was rated as adequate or good. Given the small and unequal sample sizes in each cell for this subsample (women left = 9, women ventral = 4; men left = 9, men ventral = 8), two separate one-way repeated-measures ANOVAs were conducted for women and men, collapsed across Probe Orientation, with Category as the within-subjects variable. There was a main effect of Category for women, $F(2.19, 26.30) = 7.01$, $\eta_p^2 = 0.37$, 90% CI [0.07, 0.47],

but not for men, $F(1.87, 29.85) = 0.62$, $\eta_p^2 = 0.04$ [0.00, 0.15].

Analyses performed using the subsample of 13 women with adequate or good APA waveforms produced effect sizes and an overall pattern of results that were highly similar to the full sample of women. The High-Intensity Sexual category elicited greater APA compared to all other stimulus categories: Neutral, $g = 0.59$, 95% CI [0.03, 1.24]; Exhilarating, $g = 0.74$ [0.27, 1.32]; Anxiety, $g = 0.61$ [0.15, 1.16]; Nonsexual Interaction, $g = 0.61$ [0.14, 1.16]; Low-Intensity Sexual, $g = 0.31$ [–0.03, 0.69]. APA was higher for the Low-Intensity Sexual category compared to the Nonsexual Interaction, $g = 0.29$ [0.01, 0.60]. The Exhilarating and the Anxiety categories elicited lower or similar APA as Neutral: $g = –0.23$ [–0.46, –0.03], and $g = –0.06$ [–0.40, 0.26], respectively.

Sexual Concordance

Sexual concordance was calculated using within-subjects correlations between mean APA and change in continuous self-reported sexual arousal. Concordance was calculated across all 12 experimental trials and for only female–male stimuli (nonsexual interaction, low-intensity sexual, high-intensity sexual) to account for the possibility that the low variance in genital and self-reported responses to the neutral and nonsexual affective stimuli could affect the size of the correlations. For women, the within-subjects correlation across all experimental trials was $r = .52$, 95% CI [.26, .72], and for only the female–male stimuli was $r = .60$ [.30, .79]. For men, the within-subjects correlation across all experimental trials was $r = .34$ [.002, .61], and across female–male stimuli only was $r = .31$ [–.11, .63].

Participant Feedback

In response to a questionnaire item asking if the APG was uncomfortable, participants responded “not at all” (women = 35%; men = 40%), “a little bit” (women = 45%; men = 50%),

and "somewhat" (women = 20%; men = 10%).[4] Several participants commented that the sexual films were not as sexually arousing as expected because they were dated and did not include sex-associated sounds (e.g., moaning). Positive comments were provided about the provision of the personal lubricant. During verbal debriefing, no participants voiced concerns about the APG or testing procedures. It is also noteworthy that the ease of participant recruitment was comparable to VPP studies in our laboratory.

Discussion

A commonly used measure of female genital response is the VPP, which assesses VPA as an index of vasocongestion within the vaginal canal. In this study, we examined whether the VPP could detect a sexual response when inserted anally to assess vasocongestion within the anal canal of women and men. This idea was based on research by Bohlen and Held (1979) and later Carmichael and colleagues (1987, 1994) who documented the use of an anal probe that contained a photoplethysmograph and a measure of muscle activity (either a pressure transducer or an EMG). Both groups of researchers documented changes in vascular and muscular activity at orgasm, induced via manual self-stimulation. An important advantage of employing anal photoplethysmography in the assessment of physiological sexual arousal is that the same instrument can be administered identically in both sexes. Existing measures of genital response are appropriate for comparing within-gender/sex patterns of sexual response, but are problematic when applied to the study of between-gender/sex differences due to anatomical and physiological differences between female and male genitalia. Although anal photoplethysmography has been used by other groups of researchers, this was the first study to: assess the specificity of APG as a measure of sexual response; assess anal vasocongestion to audiovisual sexual stimuli; and test

[4] When a similar question was asked in a recent VPP study in our laboratory (Sawatsky & Lalumière, 2020), women responded "not at all" (67%), "a little bit" (30%), and "definitely" (3%) uncomfortable.

the sensitivity of APG to differences in sexual activity intensity.

Results of the current study did not provide a straightforward answer to the question of whether or not the APG can be used to compare female and male sexual responding. In part, this was due to differences in APA responsivity in women and men. Women evidenced increases in APA, presumed to be a marker of anal vasocongestion, in response to sexual stimuli only, thus providing evidence of sexual response specificity for APG in women. Nonsexual stimuli that elicited nonsexual positive and negative affective responses (exhilarating and anxiety-provoking stimuli, respectively) did not elicit increases in anal vasocongestion (on average), which supports the discriminative validity of the APG. In women, APG also demonstrated sensitivity to variation in sexual activity intensity: APA was higher for stimuli portraying female–male sexual intercourse compared to a partially-clothed couple kissing and caressing, and both of these sexual categories elicited greater APA compared to a nonsexual female–male interaction. The pattern of APA across stimulus categories was unaffected by the orientation of the probe (i.e., whether the light source and detector were faced ventrally or to the left). Furthermore, despite highly variable stimulus baselines for most women and the low correlation between mean APA and MMB APA, a similar pattern of results was found when the analyses were performed using MMB. Taken together, the results suggest that APG is a sensitive and specificity measure of sexual response in women.

For men, there was weak support for the utility of the APG as a measure of sexual response, at least with its current configuration and associated methodology. Increases in APA were observed for only the high-intensity intercourse stimulus and when using the ventral probe orientation. In fact, APA for the left probe orientation appeared to decrease in response to sexual stimulus categories. It should be noted, however, that all comparisons between stimulus categories for the left probe orientation produced confidence intervals that were large and

crossed zero suggesting that the observed decrease in APA for sexual stimuli could be a spurious finding. For the ventral orientation, APA was greater for the high-intensity intercourse stimulus compared to the nonsexual interaction and the neutral stimulus categories, but the effect sizes were much lower compared to those of women (g = 0.18–0.22 versus g = 0.48–0.50, respectively) and the confidence intervals approached zero. According to data presented in Voorham-van der Zalm et al. (2013), the ventral oriented photoplethysmograph in the current study—with the light detector and source located approximately 30 and 40 mm, respectively, from the anal verge—may have faced the prostate, possibly accounting for the increase in APA for this orientation. There was no increase in APA for the anxiety or exhilarating stimulus categories relative to the neutral category for either orientation. The maximal APA response for the majority of men was to a sexual category, suggesting that the APG detected a sexual response, to some extent, in most men. It is possible that the physiological process captured by the APA is a weak or unreliable marker of sexual arousal in men or that the signal was obscured by other physiological processes that are more prominent in men—a point that is discussed in more detail below.

A methodological factor that may have influenced the relatively small effect of sexual stimulation on men's APA may be the sexual appeal of the stimuli that were presented. Several women and men commented in the questionnaire and during debriefing that the sexual films were not adequately arousing because they were dated and did not include sexual sound effects. The impact of insufficient self-reported sexual arousal on APA may be greater for men than women because self-reported sexual arousal is more strongly linked with genital response in men (meta-analysis by Chivers et al., 2010). For women, a substantial increase in vaginal vasocongestion can be elicited when feelings of sexual arousal are minimal or absent (e.g., Chivers & Bailey, 2005; Laan & Everaerd, 1995).

The average change in continuous self-reported sexual arousal for the high-intensity sexual stimulus was 26 for women and 29 for men on a 100-point scale (100 represented the maximum degree of sexual arousal). Unfortunately, we could not compare continuous self-reported sexual arousal ratings in the present study to those reported by Suschinsky et al. (2009), who used the same sexual stimuli and assessed VPP responses, because they reported *z*-transformed scores. A recent study in our laboratory that used newer commercially available films depicting female–male intercourse found that the average change (MMB) in continuous self-reported sexual arousal was 25 for women and 43 for men on a 100-point scale (unpublished data collected as part of Sawatsky et al., 2018 and Sawatsky et al., 2020). These findings support the idea that the films in the current study may not have been sufficiently sexually arousing to elicit substantial increases in APA, especially for men.

Another explanation for the lesser effect of sexual stimuli on APA in men is that blood may have been diverted from the anus and pelvic regions to the penis to facilitate erection. If this were the case, however, we would expect a decrease in APA in response to sexual stimuli relative to nonsexual stimuli, which was not consistently observed for men. Concurrent assessment with APG and PPG would clarify the relationships between anal and penile vasocongestion and whether men were sufficiently genitally aroused to exhibit a simultaneous increase in APA.

On average, men's APA values were much higher than those observed for women. Murad-Regadas et al. (2018) observed sex differences in resting state vascularization for only some anal structures, and this was due to a wider range (higher upper end) of vascularity index values among men; this is consistent with our results showing a larger range of APA values for men due to higher upper end values. To illustrate, male APA scores ranged from 0.44–55.0 mV across all trials, whereas women's ranged from 0.60–11.29 mV. Should APG be validated in

men, comparisons of female and male sexual response patterns would require within-subjects data standardization to account for the larger variability of APA values among men.

APA showed a strong, positive correlation with continuous self-reported sexual arousal in women and men, which is traditionally considered evidence of convergent validity (but see Chivers & Brotto, 2017). Although the within-subjects correlations for men (r = .31–34) were lower than is typically observed with PPG (r = .66 in Chivers et al., 2010; r = .59–.66 in Suschinsky et al., 2009) and the confidence intervals approached or crossed zero, the size of the correlation suggests that the APG detected some degree of sexual response in men. For women, the within-subjects correlations (r = .52–.60) were higher than what is typically observed for VPA (r = .27 in the Chivers et al., 2010 meta-analysis; r = .29–.48 in Suschinsky et al., 2009). High concordance for women in this study is consistent with research showing that concordance estimates are influenced by measurement device. Higher concordance in women has been observed for genital temperature compared to VPA (r = .55 vs. r = .27, respectively; Chivers et al., 2010), and lubrication compared to VPA (r = .66 vs. r = .44, respectively; Sawatsky et al., 2018). Also, presenting a number of stimulus trials and including various stimulus categories could conceivably contribute to stronger concordance estimates because the potential for response variability is increased. In their meta-analysis, Chivers et al. (2010) found that the number of data points did not substantially impact concordance estimates, but stimulus variability (defined as at least two types of sexual stimulus categories) strengthened concordance estimates in women, but not in men; therefore, the number of stimulus categories in the current study may have contributed to the high concordance scores observed for women. Nonetheless, the strong positive correlations between women's APA and self-reported sexual arousal in this study suggest that the APG captured sexual arousal in women.

Relative to VPP, the waveforms produced by the APG appeared less uniform and

smooth, and the oscillatory peaks and troughs varied less symmetrically around the midline of the wave. It is possible that the AC signal waveform simply has a different morphology within the anus compared to the vaginal canal, and that this is not problematic in terms of its validity or reliability as an indicator of sexual arousal. In support of this possibility, excluding participants whose waveform morphology was rated as poor produced a highly similar pattern of results as the full sample. Also, the waveforms of female participants were more likely to be rated as poor and, despite this, sexual response detection was stronger in women. The fact that men's waveforms had better ratings overall suggests that the APG results for men were not due to poor waveform morphology. Studies from other disciplines have also documented that the properties and features of waveforms generated by the same instrument vary depending on the site of administration (e.g., Cole & Voytek, 2017; Hartmann et al., 2019).

Alternatively, interference from another physiological process may have obscured the APG signal and data output. Bohlen and Held's (1979) detailed description and rationale for the design of their anal probe provides valuable information in this regard. The Bohlen and Held anal probe included a flexible-walled silicone air chamber designed to compress with increased muscular pressure or tension within the anus. The flexible chamber was intended to reduce pressure on the capillaries that is caused by involuntary contact pressure between the probe and anal musculature. Bohlen and Held explained that contact pressure could lead to vascular blanching (i.e., blood forced from the tissue), which could result in spurious decreases in blood volume and pulse amplitude. Bohlen and Held postulated that vascular blanching could be circumvented by the air chamber because compression would occur within the chamber rather than within the capillaries.

The rigid probe configuration of the APG in the current study may have resulted in direct pressure on the capillaries. The anus is a potential space and so insertion places the anal muscles

under some degree of tension. If the muscle tension was consistent across the duration of all experimental trials, the impact on APG data may not be problematic in a within-subjects experimental design. However, pelvic floor muscles are actively involved in the sexual response and involuntarily contract during sexual arousal (e.g., Hannan-Leith et al., 2019; reviewed by Rosenbaum, 2007). Contraction of the anal muscles during sexual arousal, as well as contact pressure between the APG probe and the anal capillaries may have interfered with the APG signal and obscured the data. The activation of anal musculature has mostly been assessed during orgasm, whereas less is known about normative anal muscle activity in men and women during other aspects or phases of sexual response. Carmichael et al. (1994) reported that anal EMG (and anal photoplethysmography) amplitudes were substantially higher during orgasm for men than women. Anal EMG amplitudes during sexual stimulation (prior to orgasm) appeared similar in women and men based on visual inspection of the figures, but statistical comparisons were not performed.

Other research has shown a greater capacity for anal muscle tension in men than women during sexually non-aroused states. Voorham-van der Zalm et al. (2013) used a multiple electrode EMG anal probe to examined sex differences of the puborectalis muscle and the EAS during resting state and voluntary contraction. The only significant sex difference between men and nulliparous premenopausal women was the strength of the EAS voluntary contraction, which was stronger in men. To our knowledge, involuntary anal muscle contraction strength during sexual arousal prior to orgasm has not been directly compared in women and men. If anal muscular activity was stronger in men and contributed to increased vascular blanching in the current study, this could explain the smaller effect of sexual stimuli on APA in men compared to women. On the other hand, APA values were larger for men, on average, which could be interpreted as a high degree of anal vasocongestion—an interpretation that is inconsistent with

vascular blanching.

According to Bohlen and Held (1979), muscle tension interference affects both the DC and AC signals (i.e., blood volume and pulse, respectively). For blood volume, anal tension results in an artificial decrease in response. For blood pulse (i.e., APA), anal tension results in "irregularly varying amplitude and non-uniform waveforms" (Bohlen & Held, 1979; p. 320). This description supports our hypothesis that the unusual waveform morphology and the relatively high number of artifacts in the current study may have been, at least in part, due to muscle interference. Contact pressure and muscle activity are less of a concern for VPP compared to APG due to the anatomical differences in muscle tonicity and vaginal canal width (Barnhart et al., 2006; Bohlen et al., 1982; Huebner et al., 2007). To investigate Bohlen and Held's observation regarding blood volume and pulse, future research can record and compare the DC and AC response patterns for APG.

Carmichael et al. (1994) were able to detect increases in photoplethysmography amplitude using an acrylic anal probe that was presumably rigid without a compressible air chamber. It is conceivable that the Carmichael et al. probe was not as sensitive to movement as the APG in our study given that their photoplethysmography data was collected during manual self-stimulation. Carmichael et al. did not comment on the quality of the photoplethysmography waveform or their data cleaning methodology, and they did not quantitatively report on amplitude change from baseline; as such, it is difficult to compare their results to those of the current study. Future research on APG may consider incorporating a flexible-walled air chamber similar to the design of Bohlen and Held (1979) in order to reduce potential muscle interference on the APG signal. Modifying the probe head to be more bulbous would also prevent potential extrusion, although participants in the current study did not report problems maintaining the probe position.

With respect to probe orientation, Bohlen and Held (1979) did not provide a justification for the ventral orientation of their photoplethysmograph light source and detector. Given that the photoplethysmograph light penetration depth is unknown (C. Hakvoort, personal communication, February 16, 2016), the ventrally oriented APG may have detected changes in vasocongestion of the prostate and vaginal canal, or other physiological events that were only detectable with the ventral orientation. It is unclear, however, why the pattern of results was different for the left probe orientation in only men if the anatomic region to the left of the anus appear similar in women and men (Regadas et al., 2007; Voorham-van der Zalm et al., 2013). The effect of probe orientation in men may have been a spurious finding. This idea is supported by the small size of the effect of probe orientation in men and the confidence intervals that approached zero. Also, the overall pattern of results for men was similar when the analyses were performed for MMB APA, but the size of the effect of probe orientation decreased and the confidence intervals crossed zero.

At this time, the impact of gender/sex and individual differences in anatomy and physiology (e.g., resting state muscle tone, muscle contraction pressure during sexual arousal, anal canal length, vascularization) on the APG signal is unknown. Investigations using concurrent ultrasound or magnetic resonance imaging (MRI) could be fruitful in this regard. Concurrent assessment with APG and PPG in men and VPP and APG in women would also elucidate the relationship between genital and anal vasocongestion. Bohlen and colleagues (Bohlen & Held, 1979; Bohlen, Held, & Sanderson, 1980; Bohlen, Held, Sanderson Ahlgren, 1982) concurrently assessed anal and genital vascular and muscular activity in women and men, but did not report on genital vasocongestion or the relationships between these physiological processes.

Limitations

There are several limitations worth considering when interpreting our results and conclusions. A limitation of the APG, as well as the VPP, is that it is unclear what response is being measured. Although it is postulated that VPP measures change in vaginal vasocongestion, this has never been proven (Prause & Janssen, 2005). Bohlen and Held (1979) postulated that when inserted anally, the photoplethysmograph detects pelvic vasocongestion. Even if the VPP and APG are measures of vasocongestion, there is no empirical evidence that the changes in blood flow within the anal canal during sexual arousal reflect broader changes in pelvic vasocongestion. Multidisciplinary collaboration and the simultaneous use of multiple assessment devices (e.g., APG, VPP, PPG, EMG, MRI) is required to determine: the physiological process that the APG (and VPP) measures; the impact of pelvic floor muscles in the assessment of pelvic vasocongestion; the depth of APG (and VPP) light penetration and diffusion; and whether the anatomical structures and physiological processes assessed by the APG are truly comparable in women and men.

We were also limited by the parameters of our hardware and signal-processing software (e.g., filtering and smoothing parameters). High- and low-frequency noise can be minimized by altering the AC band pass filter limits (Prause & Janssen, 2005). Also, a higher frequency sampling rate would allow for a more rigorous examination of signal morphology and artifacts. Research from our lab and others (e.g., Huberman & Chivers, 2015, Sawatsky & Lalumière, 2020) record pulse amplitude at 10 Hz (i.e., 10 samples/s), whereas other laboratories use higher sampling rates (e.g., 200 samples/s; Pulverman et al., 2018). An area for future research is to explore the optimal sampling rate and filtering and smoothing parameters for photoplethysmography data acquisition within the anal canal.

In terms of signal cleaning, artifacts were systematically detected and removed in a two-step process; however, given the atypical waveform features and patterns, artifacts were at times

difficult to discern from 'regular' data, which naturally contributed to some subjectivity in data cleaning. Manual artifact removal based on visual inspection of raw data is standard, yet automated tools are being developed (Prause, Williams, & Bosworth, 2010; Pulverman et al., 2018) and may become standard practice once the methods are further tested and refined. Automated artifact-detection methods may be advantageous because they would enhance standardization and are less subject to human error.

Lastly, a limitation of sexual psychophysiological studies concerns generalizability. Our inclusion and exclusion criteria and the nature of anal measurement, which may be considered invasive even relative to other psychophysiological measures, likely contributed to self-selection biases. Volunteers for sexual psychophysiological research tend to have more sexual experience and sex-positive attitudes than non-volunteers (e.g., Dawson et al., 2019); however, it is not known the extent to which individual differences meaningfully impact physiological response patterns. Analyses that included probe orientation as a between-subject factor were likely underpowered (based on only 10 participants per orientation). The small effect size of the difference in probe orientations in men may reflect a spurious finding. It will be important for future research to expand on the present study using a larger sample size.

Conclusion

The purpose of the current study was to determine whether the VPP device and methodology used in our laboratory could be applied to the assessment of anal vasocongestion as an indicator of sexual response, so that it can be used in the future to study gender/sex difference in sexual response patterns. The results suggest that the APG detected a sexual response in both women and men, but its sensitivity and specificity in men was questionable and require further investigation. We suspect that involuntary muscle contractions associated with sexual arousal and contact tension between the probe and capillaries interfered with the APG signal. Gender/sex

differences in anal musculature (e.g., Carmichael et al., 1994; Regadas et al., 2007; Voorham-van der Zalm et al., 2013) may have contributed to greater muscle activity interference in men. Also, the sexual stimuli may not have been sufficiently arousing to elicit strong anal vasocongestion responses. It is our intention that our results and their interpretation will inspire future research, such as the development of a modernized version of the Bohlen and Held (1979) anal probe that is designed to reduce muscle interference. An anal probe that is equipped for photoplethysmography and EMG assessment can be used to examine the relationship between vascular and muscle activity during sexual arousal.

Sexual psychophysiological research on gender/sex differences in sexual response patterns would benefit from a valid measure of genital or extragenital response that can be applied identically in women and men. Until then, there remains the possibility that observed gender/sex differences are the result of non-comparable instruments and/or different anatomical placement in women and men. The results of the current study indicate that, in its current configuration, the APG cannot be used to directly compare women and men's sexual response patterns. The concurrent assessment of sexual response with APG and VPP could be used to further examine the convergent validity of the APG, to test the impact of measurement device on patterns of cue-specificity, and to inform models of sexual response in women. Without a valid male-equivalent, however, examining cue-specificity using APG in women alone may not be beneficial over existing measures of female sexual response.

The desire to directly compare sexual response in women and men has led to the development of novel measurement devices; however, the physiological measurement of sexual response within the genital and pelvic area is complicated not only by differences in overall genital anatomy, but also by subtle differences in innervation, vascularization, and muscularity. Furthermore, the physiological aspects of the sexual response interact with cognitive, emotional,

and behavioral factors (see information processing model of sexual response; Janssen, Everaerd, Spiering, & Janssen, 2000), and may do so differently in women and men. In this regard, multidisciplinary collaboration is essential to expand our understanding of female and male sexual responses.

References

Barnhart, K. T., Izquierdo, A., Pretorius, E. S., Shera, D. M., Shabbout, M., & Shaunik, A. (2006). Baseline dimensions of the human vagina. *Human Reproduction, 21,* 1618–1622. doi:10.1093/humrep/del022

Beets-Tan, R. G. H., Morren, G. L., Beets, G. L., Kessels, A. G. H., el Naggar, K., Lemaire, E., & van Engelshoven, J. M. A. (2001). Measurement of anal sphincter muscles: Endoanal US, endoanal MR imaging, or phased-array MR imaging? A study with healthy volunteers. *Radiology, 220,* 81–89.

Bohlen, J. G., & Held, J. P. (1979). An anal probe for monitoring vascular and muscular events during sexual response. *Instrumentation, 16,* 318–324.

Bohlen, J. G., Held, J. P., & Sanderson, M. O. (1980). The male orgasm: Pelvic contractions measured by anal probe. *Archives of Sexual Behavior, 9,* 503-521.

Bohlen, J. G., Held, J. P., Sanderson, M. O., & Ahlgren, A. (1982). The female orgasm: Pelvic contractions. *Archives of Sexual Behavior, 11,* 367–387.

Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2009). *Introduction to meta-analysis*. West Sussex, UK: John Wiley & Sons, Ltd.

Bossio, J. A., Singh, M., & Pukall, C. F. (2018). Concurrent assessment of penile blood flow and circumference as indicators of male sexual arousal. *The Journal of Sexual Medicine, 15*(11), 1570–1578. doi:10.1016/j.jsxm.2018.08.016

Bossio, J. A., Suschinsky, K. D., Puts, D. A., & Chivers, M. L. (2014). Does menstrual cycle phase influence the gender specificity of heterosexual women's genital and subjective sexual arousal? *Archives of Sexual Behavior, 43,* 941–952. doi:10.1007/s10508-013-0233-7

Both, S., & Laan, E. (2007). Simultaneous measurement of pelvic floor muscle activity and

vaginal blood flow: A pilot study. *The Journal of Sexual Medicine, 4*(3), 690–701. doi:10.1111/j.1743-6109.2007.00457.x

Both, S., van Lunsen, R., Weijenborg, P., & Laan, E. (2012). A new device for simultaneous measurement of pelvic floor muscle activity and vaginal blood flow: A test in a nonclinical sample. *The Journal of Sexual Medicine, 9*(11), 2888–2902. doi:10.1111/j.1743-6109.2012.02910.x

Bouchard, K. N., Chivers, M. L., & Pukall, C. F. (2017). Effects of genital response measurement device and stimulus characteristics on sexual concordance in women. *The Journal of Sex Research, 54,* 1197–1208. doi:10.1080/00224499.2016.1265641

Bouchard, K. N., Timmers, A. D., & Chivers, M. L. (2015). Gender-specificity of genital response and self-reported sexual arousal in women endorsing facets of bisexuality. *Journal of Bisexuality, 15*, 180–203. doi:10.1080/15299716.2015.1022924

Boyer, S. C., Bouchard, K. N., & Pukall, C. F. (2019). Laser Doppler imaging as a measure of female sexual arousal: Further validation and methodological considerations. *Biological Psychology, 148*, 107741. doi:10.1016/j.biopsycho.2019.107741

Boyer, S. C., Pukall, C. F., & Chamberlain, S. M. (2013). Sexual arousal in women with provoked vestibulodynia: The application of laser Doppler imaging to sexual pain. *The Journal of Sexual Medicine, 10,* 1052–1064. doi:10.1111/j.1743-6109.2012.02855.x

Carmichael, M. S., Humbert, R., Dixen, J., Palmisano, G., Greenleaf, W., & Davidson, J. M. (1987). Plasma oxytocin increases in the human sexual response. *The Journal of Clinical Endocrinology, 64*, 27–31.

Carmichael, M. S., Warburton, V. L., Dixen, J., & Davidson, J. M. (1994). Relationships among cardiovascular, muscular, and oxytocin responses during human sexual activity. *Archives of Sexual Behavior, 23*, 59–79.

Chivers, M. L. (2017). The specificity of women's sexual response and its relationship with sexual orientations: A review and ten hypotheses. *Archives of Sexual Behavior, 46*, 1161–1179. doi:10.1007/s10508-016-0897-x

Chivers, M. L., & Bailey, J. M. (2005). A sex difference in features that elicit genital response. *Biological Psychology, 70*, 115–120. doi:10.1016/ j.biopsycho.2004.12.002

Chivers, M. L., Bouchard, K. N., & Timmers, A. D. (2015). Straight but not narrow; Within-gender variation in the gender-specificity of women's sexual response. *PLoS ONE, 10*, 1–21.

Chivers, M. L., Rieger, G., Latty, E., & Bailey, J. M. (2004). A sex difference in the specificity of sexual arousal. *Psychological Science, 15*, 736–744. doi:10.1111/j.0956-7976.2004.00750.x

Chivers, M. L., Roy, C., Grimbos, T., Cantor, J. M., & Seto, M. C. (2014). Specificity of sexual arousal for sexual activities in men and women with conventional and masochistic sexual interests. *Archives of Sexual Behavior, 43*, 931–940. doi:10.1007/s10508-013-0174-1

Chivers, M. L., Seto, M. C., & Blanchard, R. (2007). Gender and sexual orientation differences in sexual response to sexual activities versus gender of actors in sexual films. *Journal of Personality and Social Psychology, 93*, 1108–1121. doi:10.1037/0022-3514.93.6.1108

Chivers, M. L., Seto, M. C., Lalumière, M. L., Laan, E., & Grimbos, T. (2010). Agreement of self-reported and genital measures of sexual arousal in men and women: A meta-analysis. *Archives of Sexual Behavior, 39*, 5–56. doi:10.1007/s10508-009-9556-9

Chivers, M. L., Suschinsky, K. D., Timmers, A. D., & Bossio, J. A. (2014). Experimental, neuroimaging, and psychophysiological methods in sexuality research. In D. L. Tolman, L. M. Diamond, J. A. Bauermeister, W. H. George, J. G. Pfaus & L. M. Ward (Eds.), *APA handbook of sexuality and psychology* (Vol. 1, pp. 99-119). Washington, DC:

American Psychological Association.

Chivers, M. L., & Timmers, A. D. (2012). Effects of gender and relationship context in audio narratives on genital and subjective sexual response in heterosexual women and men. *Archives of Sexual Behavior, 41*, 185–197. doi:10.1007/s10508-012-9937-3

Dawson, S. J., Huberman, J. S., Bouchard, K. N., McInnis, M. K., Pukall, C. F., & Chivers, M. L. (2019). Effects of individual difference variables, gender, and exclusivity of sexual attraction on volunteer bias in sexuality research. *Archives of Sexual Behavior, 48*, 2403–2417. doi:10.1007/s10508-019-1451-4

Dezzutti, C. S., Brown, E. R., Moncla, B., Russo, J., Cost, M., Wang, L.,…Rohan, L. C. (2012). Is wetter better? An evaluation of over-the-counter personal lubricants for safety and anti-HIV-1 activity. *PLoS ONE, 7*(11), e48328. doi:10.1371/journal.pone.0048328

Dawson, S. J., Sawatsky, M. L., & Lalumière, M. L. (2015). Assessment of introital lubrication. *Archives of Sexual Behavior, 44*, 1527–1535. doi:10.1007/s10508-015-0519-z

Erden, A. (2017). MRI of anal canal: Normal anatomy, imaging protocol, and perianal fistulas: Part 1. *Abdominal Radiology, 43*, 1334–1352. doi:10.1007/s00261-017-1305-2

Frohlich, P. F., & Meston, C. M. (2000). Evidence that serotonin affects female sexual functioning via peripheral mechanisms. *Physiology & Behavior, 71*, 383–393.

Geer, J. H., Morokoff, P., & Greenwood, P. (1974). Sexual arousal in women: The development of a measurement device for vaginal blood volume *Archives of Sexual Behavior, 3*, 559–564.

Gerritsen, J., van der Made, F., Bloemers, J., van Ham, D., Kleiverda, G., Everaerd, W., . . . Tuiten, A. (2009). The clitoral photoplethysmograph: A new way of assessing genital arousal in women. *Journal of Sexual Medicine, 6*, 1678–1687. doi:10.1111/j.1743-6109.2009.01228.x

Graziottin, A., & Gambini, D. (2015). Anatomy and physiology of genital organs – women. *Handbook of Clinical Neurology, 130,* 39–60. doi:10.1016/b978-0-444-63247-0.00004-3

Hannan-Leith, M. N., Dayan, M., Hatfield, G., Lalumière, M. L., Albert, A. Y., & Brotto, L. A. (2019). Is pelvic floor sEMG a measure of women's sexual response? *The Journal of Sexual Medicine, 16,* 70–82. doi:10.1016/j.jsxm.2018.10.013

Hatch, J. P. (1979). Vaginal photoplethysmography: Methodological considerations. *Archives of Sexual Behavior, 8*, 357-374.

Heiman, J. R. (1977). A psychophysiological exploration of sexual arousal patterns in females and males. *Psychophysiology, 14*, 266–274.

Herbenick, D., Reece, M., Hensel, D., Sanders, S., Jozkowski, K., & Fortenberry, J. D. (2011). Association of lubricant use with women's sexual pleasure, sexual satisfaction, and genital symptoms: A prospective daily diary study. *The Journal of Sexual Medicine, 8,* 202–212. doi:10.1111/j.1743-6109.2010.02067.x

Huberman, J. S., & Chivers, M. L. (2015). Examining gender-specificity of sexual response with concurrent thermography and plethysmography. *Psychophysiology, 52,* 1382–1395. doi:10.1111/psyp.12466

Huebner, M., Margulies, R. U., Fenner, D. E., Ashton-Miller, J. A., Bitar, K. N., & DeLancey, J. O. L. (2007). Age effects on internal anal sphincter thickness and diameter in nulliparous females. *Diseases of the Colon & Rectum, 50*, 1405–1411. doi:10.1007/s10350-006-0877-7

Janssen, E. (2002). Psychophysiological measurement of sexual arousal. In M. W. Wiederman & B. E. Whitley (Eds.), *Handbook for conducting research on human sexuality* (pp. 139–171). Mahwah, NJ: Erlbaum.

Janssen, E., Everaerd, W., Spiering, M., & Janssen, J. (2000). Automatic processes and the

appraisal of sexual stimuli: Toward an information processing model of sexual arousal. *Journal of Sex Research, 37,* 8-23. doi:10.1080/00224490009552016

Janssen, E., & Prause, N. (2016). Sexual response. In J. T. Cacioppo, L. G. Tassinary & G. G. Berntson (Eds.), *Handbook of psychophysiology* (4th ed., pp. 284–299): New York, NY: Cambridge University Press.

Kaufman, J. M., Borges, F. D., Fitch, W. P., Geller, R. A., Gruber, M. B., Hubbard, J. G., . . . Witten, F. R. (1993). Evaluation of erectile dysfunction by dynamic infusion cavernosometry and cavernosography (DICC) multi-institutional study. *Urology, 41,* 445–451.

Kinsey, A. C., Pomeroy, W. B., & Martin, C. E. (1948). *Sexual behavior in the human male*. Philadelphia, PA: W. B. Saunders Company.

Kinsey, A. C., Pomeroy, W. B., Martin, C. E., & Gebhard, P. H. (1953). *Sexual behavior in the human female*. Philadelphia, PA: W. B. Saunders Company.

Kuban, M., Barbaree, H. E., & Blanchard, R. (1999). A comparison of volume and circumference phallometry: Response magnitude and method agreement. *Archives of Sexual Behavior, 28*, 345–359.

Kukkonen, T. M., Binik, Y. M., Amsel, R., & Carrier, S. (2007). Thermography as a physiological measure of sexual arousal in both men and women. *The Journal of Sexual Medicine, 4,* 93–105. doi:10.1111/j.1743-6109.2006.00399.x

Kukkonen, T. M., Binik, Y. M., Amsel, R., & Carrier, S. (2010). An evaluation of the validity of thermography as a physiological measure of sexual arousal in a non-university adult sample. *Archives of Sexual Behavior, 39,* 861–873. doi:10.1007/s10508-009-9496-4

Kukkonen, T. M. (2014). What is the best method of measuring the physiology of female sexual arousal? *Current Sexual Health Reports, 6,* 30–37. doi:10.1007/s11930-013-0010-6

Kukkonen, T. M. (2015). Devices and methods to measure female sexual arousal. *Sexual Medicine Reviews, 3,* 225–244. doi:10.1002/smrj.58

Laan, E., & Everaerd, W. (1995). Determinants of female sexual arousal: Psychophysiological theory and data. *Annual Review of Sex Research, 6,* 32–76. doi:10.1080/10532528.1995.10559901

Laan, E., Everaerd, W., & Evers, A. (1995). Assessment of female sexual arousal: Response specificity and construct validity. *Psychophysiology, 32,* 476–485. doi:10.1111/j.1469-8986.1995.tb02099.x

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. *Frontiers in Psychology, 4,* 863. doi:10.3389/fpsyg.2013.00863

Lalumière, M. L. (2017). On the concept of category-specificity. *Archives of Sexual Behavior, 46,* 1187–1190. doi:10.1007/s10508-017-0965-x

Lalumière, M. L., Sawatsky, M. L., Dawson, S. J., & Suschinsky, K. D. (2020). The empirical status of preparation hypothesis: Explicating women's genital responses to sexual stimuli in the laboratory. *Archives of Sexual Behavior.* Advanced online publication. doi:10.1007/s10508-019-01599-5

Lamprecht, V. M., & Grummer-Strawn, L. (1996). Development of new formulas to identify the fertile time of the menstrual cycle. *Contraception, 54,* 339–343.

Levin, R., & Riley, A. (2007). The physiology of human sexual function. *Psychiatry, 6,* 90–94. doi:10.1016/j.mppsy.2007.01.004

Mamatha, H., Hemalatha, B., Vinodini, P., Souza, A. S. D., & Suhani, S. (2012). Anatomical study on the variations in the branching pattern of internal iliac artery. *Indian Journal of Surgery, 77,* 248–252. doi:10.1007/s12262-012-0785-0

Maravilla, K. R., & Yang, C. C. (2008). Magnetic resonance imaging and the female sexual response: Overview of techniques, results, and future directions. *The Journal of Sexual Medicine, 5,* 1559–1571. doi:10.1111/j.1743-6109.2008.00839.x

Masters, W. H., & Johnson, V. E. (1966). *The human sexual response*. Boston, MA: Little, Brown & Co.

Mechelmans, D. J., Sachtler, W. L., von Wiegand, T. E., Goodrich, D., Heiman, J. R., & Janssen, E. (2017, July). *Finding CPD: The successful measurement of clitoral pulse amplitude using a new clitoral plethysmograph*. Poster presented at the International Academy of Sex Research Meeting, Charleston, SC.

Meston, C. M., & Gorzalka, B. B. (1996). The effects of immediate, delayed, and residual sympathetic activation on sexual arousal in women. *Behaviour Research and Therapy, 34*, 143–148. doi:10.1016/0005-7967(95)00050-x

Murad-Regadas, S. M., Regadas, F. S. P., Dealcanfreitas, I. D., Regadas Filho, F. S. P., Fernandes, G. O. d. S., Albuquerque, M. C. F., . . . Regadas, M. M. (2018). Establishing the normal ranges of female and male anal canal and rectal wall vascularity with color Doppler anorectal ultrasonography. *Journal of Coloproctology*, *38*, 207–213. doi:10.1016/j.jcol.2018.03.005

Nielsen, M. B., Hauge, C., Rasmussen, O. Ø., Sørensen, M., Pedersen, J. F., & Christiansen, J. (1992). Anal sphincter size measured by endosonography in healthy volunteers. *Acta Radiologica, 33*, 453–456. doi:10.1080/02841859209172033

Nivatvongs, S., Stern, H. S., & Fryd, D. S. (1981). The length of the anal canal. *Diseases of the Colon & Rectum, 24*, 600–601.

O'Brien, F., & Cousineau, D. (2014). Representing error bars in within-subject designs in typical software packages. *Tutorials in Quantitative Methods for Psychology, 10*, 56–67.

Oliver, M. B., & Hyde, J. S. (1993). Gender differences in sexuality: A meta-analysis. *Psychological Bulletin, 114*, 29–51.

Osborn, C. A., & Pollack, R. H. (1977). The effects of two types of erotic literature on physiological and verbal measures of female sexual arousal. *Journal of Sex Research, 13*, 250–256.

Peterson, J. L., & Hyde, J. S. (2010). A meta-analytic review of research on gender differences in sexuality, 1993–2007. *Psychological Bulletin, 136*, 21–38. doi:10.1037/a0017504.supp

Peterson, Z. D., Janssen, E., & Laan, E. (2010). Women's sexual responses to heterosexual and lesbian erotica: The role of stimulus intensity, affective reaction, and sexual history. *Archives of Sexual Behavior, 39*, 880–897. doi:10.1007/s10508-009-9546-y

Prause, N., & Janssen, E. (2005). Blood flow: Vaginal photoplethysmography. In I. Goldstein, C. M. Meston, S. Davis & A. Traish (Eds.), *Women's sexual function and dysfunction: Study, diagnosis and treatment* (pp. 361–369). London, UK: Taylor & Francis Medical Books.

Prause, N., Williams, K., & Bosworth, K. (2010). Wavelet denoising of vaginal pulse amplitude. *Psychophysiology, 47*, 393–401. doi:10.1111/j.1469-8986.2009.00941.x

Pulverman, C. S., Hixon, J. G., & Meston, C. M. (2015). Uncovering category specificity of genital sexual arousal in women: The critical role of analytic technique. *Psychophysiology, 10*, 1396–1408. doi:10.1111/psyp.12467

Regadas, F. S. P., Murad-Regadas, S. M., Lima, D. M. R., Silva, F. R., Barreto, R. G. L., Souza, M. H. L. P., & Filho, F. S. P. R. (2007). Anal canal anatomy showed by three-dimensional anorectal ultrasonography. *Surgical Endoscopy, 21*, 2207–2211. doi:10.1007/s00464-007-9339-0

Rieger, G., Cash, B. M., Merrill, S. M., Jones-Rounds, J., Dharmavaram, S. M., & Savin-

Williams, R. C. (2015). Sexual arousal: The correspondence of eyes and genitals. *Biological Psychology, 104*, 56–64. doi:10.1016/j.biopsycho.2014.11.009

Rociu, E., Stoker, J., Eijkemans, M. J. C., & Laméris, J. C. (2000). Normal anal sphincter anatomy and age- and sex-related variations at high-spatial-resolution endoanal MR imaging. *Radiology, 217*, 395–401.

Rosenbaum, T. Y. (2007). Pelvic floor involvement in male and female sexual dysfunction and the role of pelvic floor rehabilitation in treatment: A literature review. *The Journal of Sexual Medicine, 4*, 4–13. doi:10.1111/j.1743-6109.2006.00393.x

Rupp, H. A., & Wallen, K. (2008). Sex differences in response to visual sexual stimuli: A review. *Archives of Sexual Behavior, 37*, 206–218. doi:10.1007/s10508-007-9217-9

Sakheim, D. K., Barlow, D. H., Beck, J. G., & Abrahamson, D. J. (1985). A comparison of male heterosexual and male homosexual patterns of sexual arousal. *The Journal of Sex Research, 21*, 183–198. doi:10.1080/00224498509551257

Sawatsky, M. L., Dawson, S. J., & Lalumière, M. L. (2018). Genital lubrication: A cue-specific sexual response? *Biological Psychology, 134*, 103–113. doi:10.1016/j.biopsycho.2018.02.003

Sawatsky, M. L., & Lalumière, M. L. (2020). Effect of a condom cover on vaginal photoplethysmographic responses. *Journal of Sexual Medicine*. Advanced online publication. doi:10.1016/j.jsxm.2019.12.021

Sawatsky, M. L., Lavrinsek, S., Dawson, S. J., & Lalumière, M. L. (2020). Time course of genital response cue-specificity. *The Canadian Journal of Human Sexuality*. Advanced online publication. doi:10.3138/cjhs.2019-0064

Serretti, A., & Chiesa, A. (2009). Treatment-emergent sexual dysfunction related to antidepressants: A meta-analysis. *Journal of Clinical Psychopharmacology, 29*, 259–266.

doi:10.1097/JCP.0b013e3181a5233f

Spape, J., Timmers, A. D., Yoon, S., Ponseti, J., & Chivers, M. L. (2014). Gender-specific genital and subjective sexual arousal to prepotent sexual features in heterosexual women and men. *Biological Psychology, 102*, 1–9. doi:10.1016/j.biopsycho.2014.07.008

Styles, S. J., MacLean, A. B., Reid, W. M. N., & Sultana, S. R. (2006). Laser Doppler perfusion imaging: A method for measuring female sexual response. *BJOG: An International Journal of Obstetrics & Gynaecology, 113*, 599–601. doi:10.1111/j.1471-0528.2006.00894.x

Suschinsky, K. D., Dawson, S. J., & Chivers, M. L. (2020). Assessing gender-specificity of clitoral responses. *The Canadian Journal of Human Sexuality*. Advanced online publication. doi:10.3138/cjhs.2019-0061

Suschinsky, K. D., & Lalumière, M. L. (2011a). Prepared for anything?: An investigation of female genital arousal in response to rape cues. *Psychological Science, 22*, 159-165. doi:10.1177/0956797610394660

Suschinsky, K. D., & Lalumière, M. L. (2011b). Category-specificity and sexual concordance: The stability of sex differences in sexual arousal patterns. *The Canadian Journal of Human Sexuality, 20*, 93-108.

Suschinsky, K. D., Lalumière, M. L., & Chivers, M. L. (2009). Sex differences in patterns of genital sexual arousal: Measurement artifacts or true phenomena? *Archives of Sexual Behavior, 38*, 559–573. doi:10.1007/s10508-008-9339-8

Suschinsky, K. D., Shelley, A. J., Gerritsen, J., Tuiten, A., & Chivers, M. L. (2015). The clitoral photoplethysmograph: A pilot study examining discriminant and convergent validity. *The Journal of Sexual Medicine, 12*, 2324–2338. doi:10.1111/jsm.13047

Tabachnick, B. G., & Fidell, L. S. (2007). Experimental design using ANOVA. Belmont, CA:

Thomson Brooks/Cole.

Tavares, I. M., Vardasca, R., Cera, N., Pereira, R., Nimbi, F. M., Lisy, D., . . . Nobre, P. J. (2018). A review of infrared thermography as applied to human sexual psychophysiology. *International Journal of Psychophysiology, 133*, 28–40. doi:10.1016/j.ijpsycho.2018.09.001

Timmers, A. D. (2019). *Attractiveness and sexual response.* (Doctoral Dissertation). Queen's University, Kingston, Ontario, Canada.

Timmers, A. D., Bouchard, K. N., & Chivers, M. L. (2015). Effects of gender and sexual activity cues on the sexual responses of women with multidimensionally defined bisexuality. *Journal of Bisexuality, 15*, 154–179. doi:10.1080/15299716.2015.1023389

van Anders, S. M. (2015). Beyond sexual orientation: Integrating gender/sex and diverse sexualities via sexual configurations theory. *Archives of Sexual Behavior, 44*, 1177–1213. doi:10.1007/s10508-015-0490-8

Voorham-van der Zalm, P. J., Voorham, J. C., van den Bos, T. W. L., Ouwerkerk, T. J., Putter, H., Wasser, M. N. J. M., . . . Pelger, R. C. M. (2013). Reliability and differentiation of pelvic floor muscle electromyography measurements in healthy volunteers using a new device: The multiple array probe leiden (MAPLe). *Neurourology and Urodynamics, 32*, 341–348. doi:10.1002/nau.22311

Waxman, S. E., & Pukall, C. F. (2009). Laser Doppler imaging of genital blood flow: A direct measure of female sexual arousal. *The Journal of Sexual Medicine, 6*, 2278–2285. doi:10.1111/j.1743-6109.2009.01326.x

Zuckerman, M. (1971). Physiological measures of sexual arousal in the human. *Psychological Bulletin, 75*, 297–329.

Table 5.1

Means and Standard Deviations of Ratings for the Post-Stimulus Affect and Sexual Arousal Questions for Each Stimulus Category, Collapsed Across Participant Gender/Sex

	Neutral		Exhilarating		Anxiety		Nonsexual Interaction		Low-Intensity Sexual		High-Intensity Sexual	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Pleasant	5.88	1.95	4.80	1.65	2.13	1.35	5.91	2.07	4.29	1.53	5.49	1.94
Unpleasant	1.30	0.52	1.68	0.87	5.10	1.87	1.23	0.61	1.65	0.96	1.48	0.53
Anxiety	1.61	0.85	2.53	1.40	4.94	2.04	1.41	0.58	1.26	0.62	1.35	0.74
Exhilarating	2.20	1.38	4.41	2.03	4.14	1.99	3.59	1.75	2.66	1.50	3.81	2.04
Intense	2.04	1.36	4.09	1.97	5.69	1.86	3.41	1.69	2.86	1.51	3.65	1.89
Erotic	1.13	0.40	1.46	1.05	1.35	0.83	2.44	1.51	3.98	1.55	5.71	2.36

Note. Ratings were on a scale from 1 (not at all) to 9 (extremely). Means were calculated by averaging the ratings for both exemplars of a stimulus category.

Table 5.2

Means and Standard Deviations for APA for Each Stimulus Category for Women and Men, Separated by Probe Orientation (Left or Ventral)

	Women				Men			
	Left		Ventral		Left		Ventral	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Neutral	3.79	1.91	2.64	1.83	10.03	9.54	8.67	11.56
Exhilarating	3.35	2.18	2.27	1.34	10.20	9.24	8.79	12.18
Anxiety	3.64	2.55	2.69	1.60	10.58	9.65	9.44	14.42
Nonsexual Interaction	3.84	2.25	2.45	1.60	9.14	8.28	9.41	12.20
Low-Intensity Sexual	4.45	2.59	3.00	2.06	7.41	6.31	10.83	14.91
High-Intensity Sexual	5.52	2.68	3.24	1.82	8.81	7.94	12.32	13.92

Note. Means were calculated by averaging APA values for both exemplars of a stimulus category.

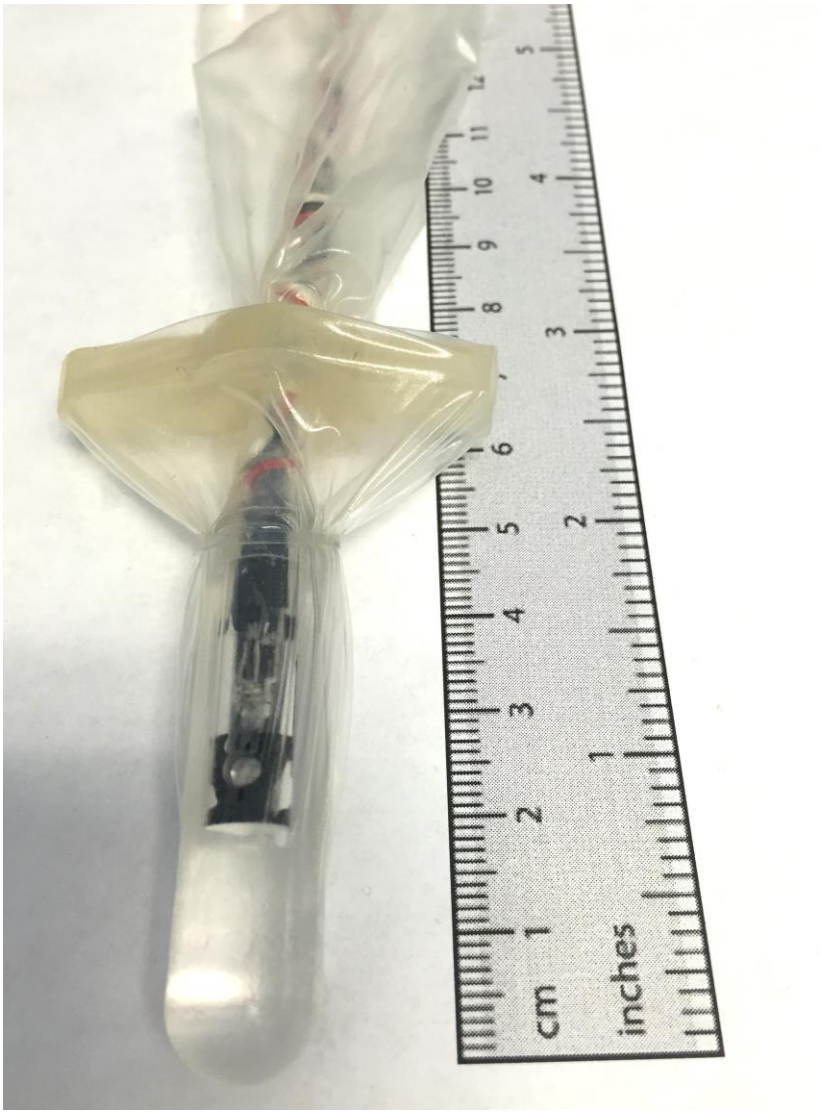

Figure 5.1. Anal photoplethysmograph (APG) with the condom cover.

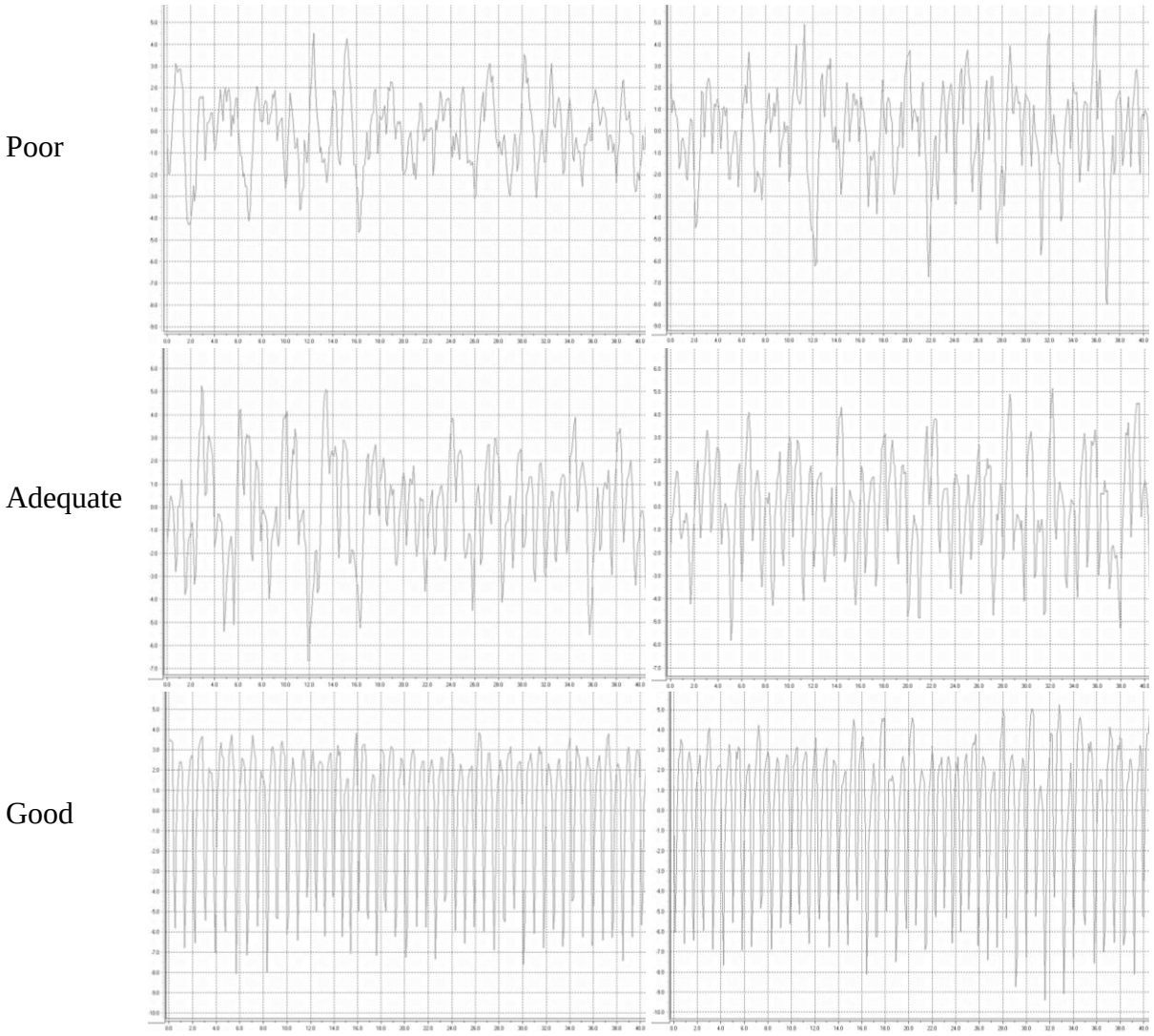

Figure 5.2. Examples of data in mV (x-axis) across time 0–40 s (y-axis) for a neutral (left) and high-intensity sexual (right) stimulus for three female participants whose waveforms were rated as either poor, adequate, or good. The y-axis varies by participant due to individual differences in APA amplitudes.

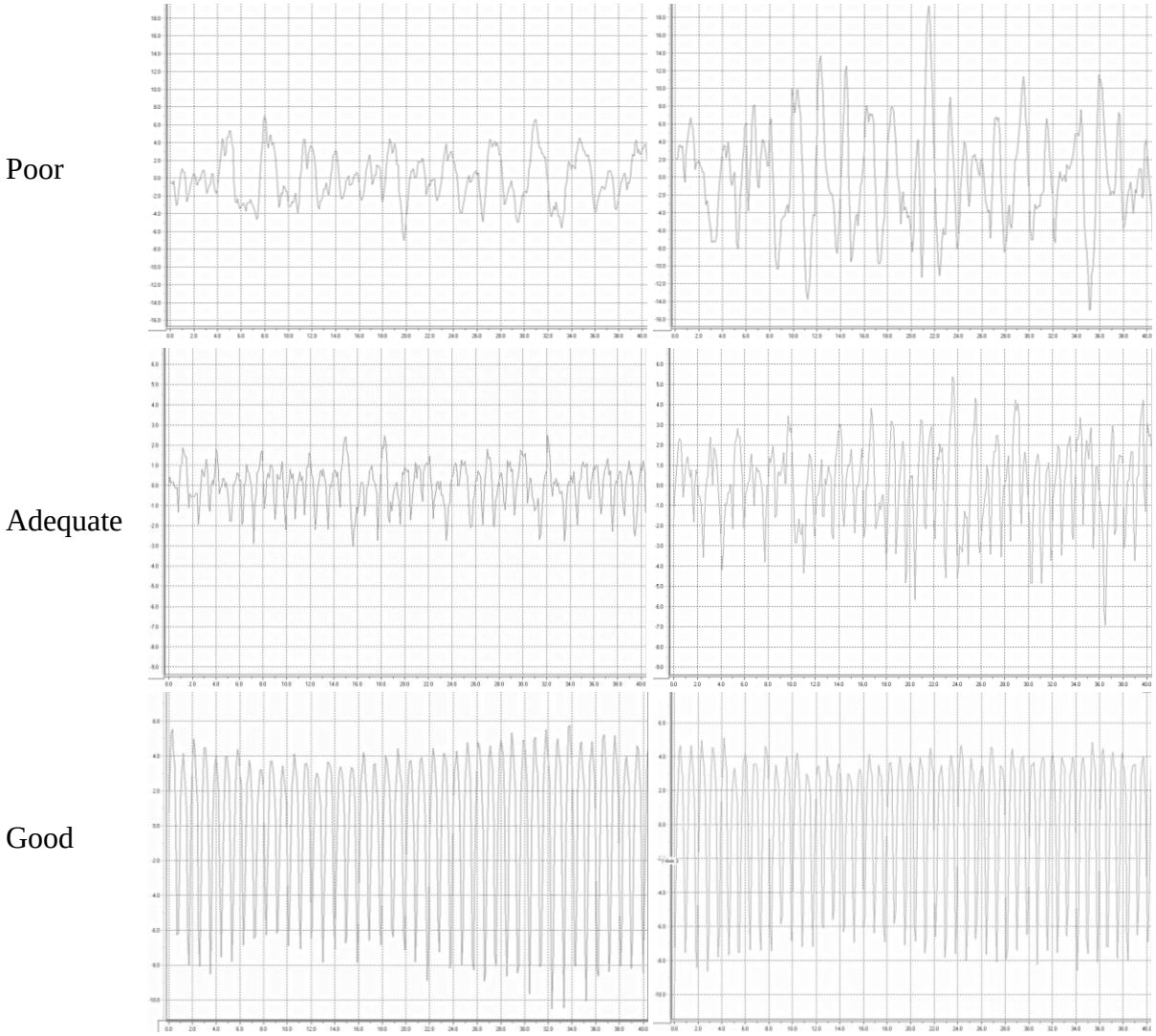

Figure 5.3. Examples of data in mV (x-axis) across time 0–40 s (y-axis) for a neutral (left) and high-intensity sexual (right) stimulus for three male participants whose waveforms were rated as either poor, adequate, or good. The y-axis varies by participant due to individual differences in APA amplitudes.

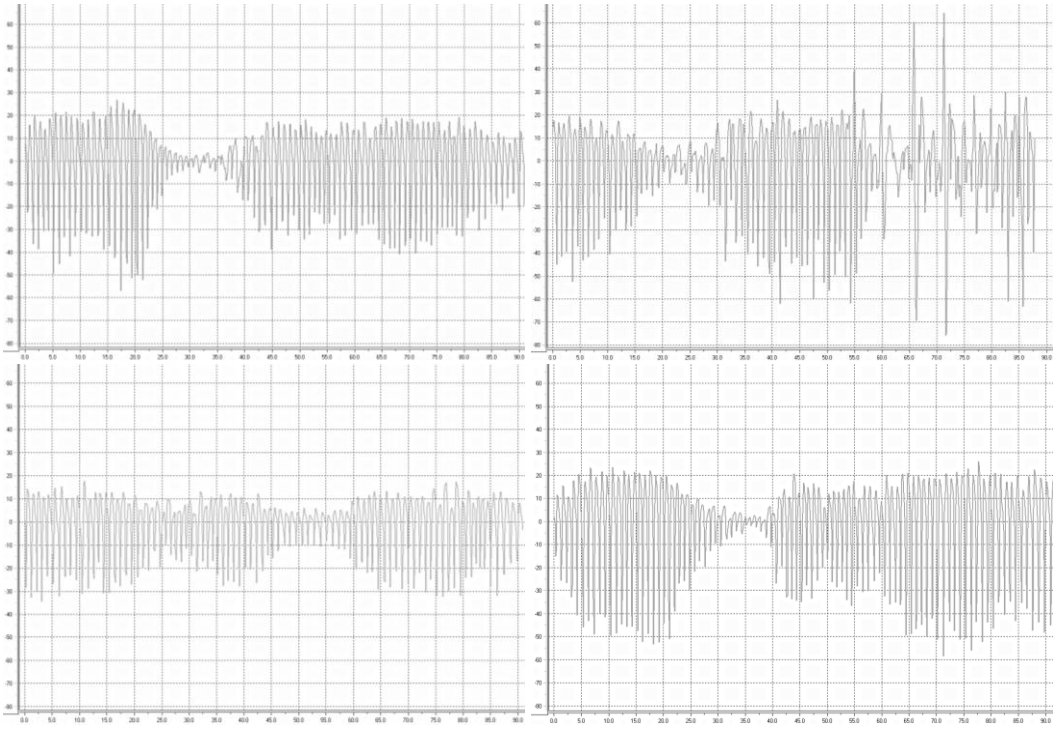

Figure 5.4. Irregular APA wave pattern in mV (x-axis) across the entire stimulus duration (y-axis) for a neutral (top left), high-intensity sexual (top right), exhilarating (bottom left), and anxiety (bottom right) stimulus from one male participant. Examples of data in mV (x-axis) across time 0–40 s (y-axis).

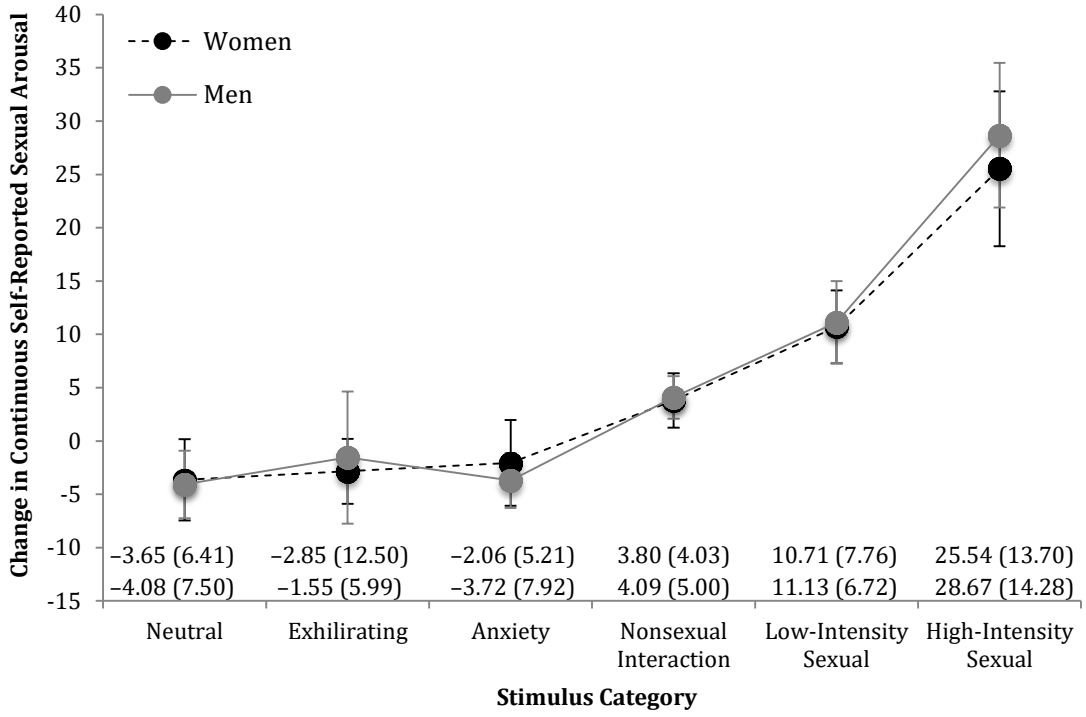

Figure 5.5. Change in continuous self-reported sexual arousal for women and men. Error bars represent 95% CI. Numerical values below each data point represent the mean and standard deviation (in parentheses) of each stimulus category, with women's data in the top row and men's in the bottom row.

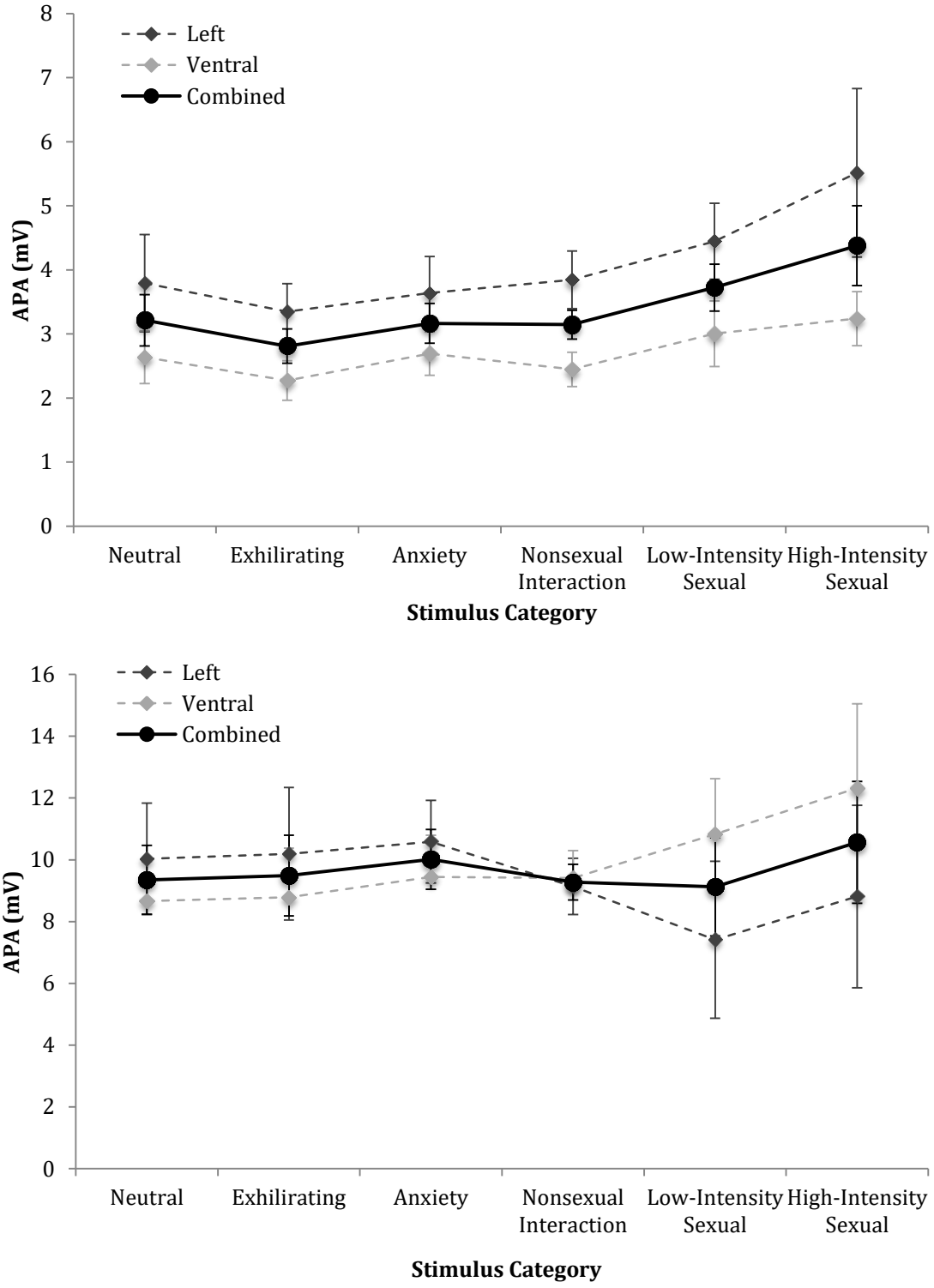

Figure 5.6. Mean APA for women (top) and men (bottom) across stimulus categories. Error bars represent 95% CI. The y-axis scale is different for women and men due to between-gender/sex APA amplitude variation.

CHAPTER 6

General Discussion

The research described in this dissertation involves the psychophysiological investigation of gender/sex differences in genital response *cue-specificity*. Men's genital responses demonstrate relatively high cue-specificity, meaning that responses differ across stimuli depending on the presence or absence of specific features or cues (e.g., gender/sex, age, sexual activities; e.g., Rieger, Chivers, & Bailey, 2005). Women's genital responses, assessed with vaginal photoplethysmography, demonstrate much lower cue-specificity and this is particularly the case for androphilic women (e.g., Chivers, Rieger, Latty, & Bailey, 2004; Rieger et al., 2015). With respect to gender/sex cues, both male and female sexual stimuli elicit a sizeable increase in vaginal vasocongestion (e.g., Chivers & Bailey, 2005; Suschinsky, Lalumière, & Chivers, 2009). For androphilic women, the size of the increase in vaginal vasocongestion is nearly identical for audiovisual sexual stimuli depicting men or women, whereas gynephilic and androgynephilic women tend to show elevated responses to those depicting women (e.g., Chivers, Seto, & Blanchard, 2007; Timmers, Bouchard, & Chivers, 2015). There is evidence that any degree of gynephilic sexual attraction in women is associated with specificity for female sexual cues, and that indiscriminate genital responses to gender/sex cues is unique to exclusively androphilic women (Bouchard, Timmers, & Chivers, 2015; Chivers, Bouchard, & Timmers, 2015; Timmers et al., 2015). There is also evidence that women of all sexual orientations demonstrate lower gender/sex cue-specificity compared to men (Chivers et al., 2007; Rieger et al., 2015). Low cue-specificity in androphilic women has also been observed for other sexual cues (e.g., consensual versus nonconsensual sex; Suschinsky & Lalumière, 2011a, 2011b) and has been replicated using other indices of genital vasocongestion (e.g., thermography; Huberman & Chivers, 2015).

A number of explanations for women's genital response patterns have been proposed (see review by Chivers, 2017). The *preparation hypothesis* (Suschinsky & Lalumière, 2011a, 2011b)

posits that low cue-specificity serves an adaptive function: Indiscriminate genital responses, specifically genital lubrication, serve to protect the vaginal tract and reproductive organs from friction-related injuries incurred through sexual intercourse (Chivers, 2005; Laan, 1994; Laan & Janssen, 2007; Suschinsky et al., 2009). It is a widely cited and compelling hypothesis, developed from observations of low cue-specificity for vaginal vasocongestion assessed with vaginal photoplethysmography. The preparation hypothesis specifically pertains to the protective function of genital lubrication, which is preceded by increases in vaginal vasocongestion (Levin, 2003); therefore, lubrication should also demonstrate low cue-specificity. Chapter Two was the first study to examine the cue-specificity of genital lubrication, thereby directly testing the preparation hypothesis.

In Chapter Two, litmus test strips (LTSs; Dawson, Sawatsky, & Lalumière, 2015) were used to quantify genital lubrication in response to stimuli that varied by actor gender/sex and sexual activity intensity (i.e., sexual explicitness). Vaginal vasocongestion was also assessed (separately from LTS, but with the same female participants) using a vaginal photoplethysmograph (VPP). Consistent with previous research, vaginal vasocongestion among androphilic women demonstrated low gender/sex cue-specificity. Unexpectedly, increases in genital lubrication were specific for sexual stimuli rated as the most sexually arousing. For instance, androphilic women (as a group) demonstrated an increase in lubrication to only male–female sexual stimuli (relative to a nonsexual stimulus).

The finding of specificity for genital lubrication is inconsistent with the preparation hypothesis, which predicts that the formation of lubrication should be indiscriminately activated any sexual cue. If vaginal vasocongestion were a precursor to genital lubrication (Levin, 2003), then it would be expected that vaginal vasocongestion and lubrication would be highly correlated; however, there was little association between genital responses assessed with the VPP

and LTS (also see Dawson et al., 2015). Physiological or methodological factors could account for these results. Not all authors agree that vasocongestion is a necessary precursor to lubrication. According to Traish, Botchevar, and Kim (2010), the idea that vaginal lubrication is mediated mainly by vaginal blood flow remains speculative. The authors reported that no biochemical mechanism linking lubrication to blood flow has been identified. In non-human species, increases in vaginal lubrication have been documented in the absence of blood flow stimulation (Min et al., 2003), suggesting that independent mechanisms may be responsible for these two aspects of genital response (Traish et al., 2010). A methodological factor that could have contributed to the lack of agreement between vaginal vasocongestion and lubrication in Chapter Two is that vasocongestion was assessed continuously during the sexual stimulus whereas lubrication was measured at a discrete time point, post-stimulus. A question that emerged from this research was whether genital responses become more cue-specific over the duration of sexual stimuli—a pattern that would not necessarily be captured using a single mean or peak value to represent a stimulus response.

In Chapter Three, VPP data collected for Chapter Two was analyzed to examine whether cue-specificity for vaginal vasocongestion might emerge over time with relatively long duration audiovisual sexual stimuli (240 s versus 60–120 s audiovisual stimuli used in most studies of cue-specificity). This was the first study to examine the time course of genital response cue-specificity for gender/sex cues using stimuli depicting different types of sexual activity (solitary and partnered sex) that elicited variation in continuously measured self-reported sexual arousal. The results demonstrated that the magnitude of the increases in vaginal vasocongestion was established by 60–90 s and showed a pattern of low cue-specificity that was maintained thereafter. The finding that cue-specificity for vaginal vasocongestion did not emerge with longer duration stimuli suggests that low cue-specificity for vaginal vasocongestion is robust to

stimulus duration. The Chapter Three results for VPP were not consistent with the observation of cue-specificity for lubrication, which was assessed at the end of the stimuli in Chapter Two.

A possible proximate explanation for the Chapter Two lubrication results, derived from the information-processing model (IPM) of sexual response (Geer, Lapour, & Jackson, 1993; Janssen, Everaerd, Spiering, & Janssen, 2000), is that the cues in the male–female sexual stimulus that were associated with positive or rewarding meanings in memory elicited increased attention, conscious cognitive elaboration, heightened emotional sexual arousal, and a full genital response (i.e., the controlled or conscious processing stage of the IPM). Janssen et al. (2000) did not specify the physiological changes that constitute a "full-blown" genital response (p. 10), but it is possible that the formation of lubrication occurs in response to more elaborative cognitive processing (unlike vaginal vasocongestion, which appears to be triggered automatically). Rather than a single sexual cue, it is likely that an amalgamation of sexual cues in the male–female sexual stimulus (e.g., sexual positions, activities, vocalisations) rendered it effective in proliferating genital lubrication and heightened feelings of sexual arousal. Male–female sex was the most frequently represented in the 1st and 2nd rank-preferred stimulus categories (rankings were based on continuous self-reported sexual arousal ratings), and only the 1st and 2nd rank-preferred stimulus categories showed an increase in lubrication. Not all androphilic women rated male–female sex as the most sexually arousing, but this is not necessarily evidence against the proposed explanation. Feelings of sexual arousal are only one of many interrelated aspects of the controlled cognitive processing stage of the IPM and may not have been fully captured by the quantitative self-report ratings. Heightened attention, positive conscious associations in memory, and the anticipation of or receptivity to experiencing sexual activity may have contributed to an overall heightened sexual response to male–female sex, including an increase in lubrication. Factors that contribute to the proliferation of lubrication are further discussed in the preparation

hypothesis implication section.

Chapters Four and Five focussed on developing methodology related to the anal photoplethysmograph to determine its potential for use in the study of gender/sex differences in cue-specificity. A proposed explanation for gender/sex differences in genital response patterns is that genital vasocongestion is quantified using different instruments for men and women (Chivers, 2017; Lalumière, Sawatsky, Dawson, & Suschinsky, 2020). Most studies showing low cue-specificity for women assess vaginal vasocongestion using VPP and compare the response patterns to those observed for penile vasocongestion measured with circumferential penile plethysmography. Not only are different devices used, but also their anatomical placement and data output are dissimilar, which renders between-gender/sex comparisons problematic. Comparing response patterns acquired using the same instrument, administered identically in men and women, would be a more direct test of whether or not the observed gender/sex differences in cue-specificity are a measurement artifact.

Bohlen and Held (1979) demonstrated that anal photoplethysmography is capable of detecting vascular activity during sexual arousal for both men and women, but this device has been rarely employed to compare male and female sexual responses (Carmichael et al., 1987; Carmichael, Warburton, Dixen, & Davidson, 1994) and has never been used to examine cue-specificity. Direct comparisons of male and female data may be more appropriate with anal plethysmography because the device, its anatomical placement, and the data output are identical for both men and women. Chapters Four and Five describe studies related to testing whether the VPP could be applied intra-anally as an anal photoplethysmograph (APG) to detect a sexual response to audiovisual sexual stimuli. The APG probe configuration and its associated methodology were to be identical to the VPP with one exception: A condom cover would be placed over the probe as a sanitary enhancement.

The idea of placing a disposable cover on the VPP probe to enhance participant safety had been discussed among sexual psychophysiology researchers (e.g., Carrito, Tavares, Pereira, & Nobre, 2019), but the impact of a protective cover on the photoplethysmograph signal and acquired data had not been empirically tested. Potential disruption to the VPP signal was tested in Chapter Four using a within-subjects design where androphilic women's genital responses were assessed with VPP in both a cover-off and cover-on condition. The magnitude of sexual response to each stimulus category, the overall pattern of results, and the average number of edited data artifacts were highly similar in the cover-off and cover-on conditions. The condom cover did not appear to meaningfully impact sexual arousal or the VPP signal, suggesting that placing a condom cover on the APG probe would not interfere with data acquisition. Another implication of the results is that researchers using VPP can integrate the use of a condom cover in their experiment protocols without disrupting data acquisition, which would comply with current guidelines for reprocessing semi-critical medical devices in many regions, including Canada, and may enhance participant safety and comfort.

The purpose of Chapter Five was to test the response specificity and sensitivity of the APG as a measure of sexual response in men and women. Results supported the discriminative validity, convergent validity, and sensitivity of the APG in women: Anal pulse amplitude (APA) specifically increased in response to only sexual stimuli (APA did not increase in response to other affective stimuli); showed high correspondence with self-reported sexual arousal; and was sensitive to sexual stimulus intensity. Results were less clear for men. There was some evidence that the APG captured a sexual response in men, but only for one probe orientation (ventral) and the effect size was small. The effect of sexual stimulation on APG responses in men may have been more pronounced if more sexually appetitive stimuli had been presented. For a number of male and female participants, the APG waveform morphology was unusual compared to that

typically observed with VPP—a finding that deserves further investigation. In its current configuration, the APG cannot be used to directly compare men and women's sexual response patterns.

Future Directions and Implications

A major focus of this dissertation was to consider and address methodological factors that may contribute to the relatively low gender/sex cue-specificity of women's genital responses, as observed in the large majority of studies. Based on the research presented here and elsewhere, it appears that measurement devices, and other experimental and individual variables influence genital response patterns observed in the laboratory—these factors are discussed below and suggestions for future research are provided. Potential implications of genital response cue-specificity on our understanding and conceptualisation of male and female sexual responses are also explored, with a particular emphasis on evaluating and refining the preparation hypothesis. Lastly, clinical implications of sexual psychophysiological research methods and findings are considered.

Genital Measurement Device

Most of our knowledge of women's genital response patterns has been acquired using VPP, which is thought to measure vaginal vasocongestion. As far back as 1979, Hatch warned of an overreliance on VPP: "…the female sexual response cycle consists of much more than a vaginal vasocongestive response, and to overemphasize the importance of this one response to the exclusion of other components of the overall response pattern would definitely be counterproductive" (p. 370). Traditionally, there has been a paucity of research on the physiology of female sexual response, perhaps due to the lack of easily recognizable physiological or anatomical markers (unlike penile erection) and the lack of universally accepted, well-validated measures to assess female genital responses (Suh et al., 2004). In more

recent years, a number of instruments have been developed to monitor different aspects of the female genital response (reviewed by Chivers, Suschinsky, Timmers, Bossio, 2014; Kukkonen, 2014, 2015; Woodard & Diamond, 2009) and efforts are being made to establish their validity and reliability (e.g., Boyer, Bouchard, & Pukall, 2019). For instance, a number of sexual psychophysiology studies have employed thermography to measure genital temperature as an index of genital vasocongestion (e.g., Huberman & Chivers, 2015; reviewed by Tavares et al., 2018). There is also accumulating research on the validity of laser Doppler imaging (LDI) as a measure of genital response in women (e.g., Bouchard, Chivers, & Pukall, 2017; Boyer et al., 2019; Styles, Maclean, Reid, Sultana, 2006; Waxman & Pukall, 2009) and recent results suggest its applicability for men (Bossio, Singh, & Pukall, 2018).

Comparing cue-specificity in men and women using a direct measure of genital blood flow, such as the LDI, is an important next step. Nonetheless, the hemodynamic demands of the penis in men and external genitalia in women are not equal and contribute to differences in blood volume and pressure of the supplying arteries (Graziottin & Gambini, 2015). Blood flow changes of the external genitalia are, therefore, not necessarily comparable in men and women. Within-subject designs and data standardization can account for some of the hemodynamic differences across participants, yet there may be greater capacity for vascular change and response variability for men compared to women. These physiological differences could contribute to gender/sex differences in genital response patterns.

Extragenital physiological measures that can be applied identically in men and women, such as anal plethysmography (if validated in men), may circumvent some of the measurement issues inherent to genital assessment. Research by Murad-Regadas et al. (2018) suggests that sex differences in vascularization may be minimized, but not eliminated, with anal assessment. Murad-Regadas et al. observed sex differences in vascularization for only some anal structures

and this was due to a wider range (higher upper end) of vascularity index values among men; this is consistent with the larger range of APA values for men compared with women, as reported in Chapter Five.

Another method that has not yet been applied to the study of cue-specificity is dynamic magnetic resonance imaging (MRI). Dynamic MRI has been used to directly examine the anatomical changes of multiple external and internal genital structures in response to audiovisual sexual stimuli (reviewed by Maravilla & Yang, 2008). Using MRI, Maravilla et al. (2005) concluded that change in clitoral volume provides the most reliable indicator of physiological sexual response in women compared with changes of the labia, vestibular bulbs, vaginal canal, and urethra. While MRI assesses structural changes of organs and tissues, magnetic resonance angiography (MRA) details blood vessels. MRA can be performed in conjunction with MRI using the same machine. Widespread use of MRI and MRA is unlikely due to cost; however, their application to the study of gender/sex differences in cue-specificity would be valuable because multiple anatomical and vascular sexual changes can be assessed simultaneously using the same device in men and women. Although there are sex differences in the hemodynamic demands of the genital structures, relative patterns of response to various categories of sexual stimuli can be compared. MRI and MRA could also be used to enhance our understanding of the time course of changes to the genitals and pelvic organs (Maravilla & Yang, 2008), thereby examining the hypothesis raised in this dissertation that vaginal vasocongestion is an initial preparatory response to any sexual cue, whereas other physiological markers of sexual response (e.g., external genital changes) may occur more selectively in response to specific cues (see Chapters Two and Three). MRI and MRA may also clarify why sexual response assessment with APG was less successful in men (Chapter Five).

Determining which instrument to employ in sexual psychophysiological research largely

depends on the research question, as well as consideration of practical issues and quantitative parameters (e.g., feasibility, cost, ease of use, duration of assessment, continuous versus discrete measurement, participant comfort). Kukkonen (2014, 2015) reviewed the benefits and drawbacks of various measures of female genital responses. In terms of research questions, for example, VPP is not a reliable measure of sexual preference and is not suitable for studying sexual preferences and interests (e.g., paraphilic interests). If the degree of lubrication is affected by sexual preferences and the LTS can reliably assess lubrication, then the LTS would be a more appropriate measure. When testing of new techniques to assess genital responses, there are benefits to concurrently administering VPP because it is a valid measure of sexual response (Laan, Everaerd, & Evers, 1995; Suschinsky et al., 2009). Concurrent use of multiple physiological indicators of sexual response (e.g., Bouchard et al., 2017, 2019; Huberman & Chivers, 2015; Chapter Two) can provide important information about the relationships between different physiological sexual changes and will help to formulate a more comprehensive understanding of genital response patterns.

Concurrent assessment with multiple instruments is particularly important in light of accumulating evidence that patterns of cue-specificity and concordance vary depending on the measurement device and the physiological process assessed. For instance, several studies on sexual concordance have demonstrated that measures of external genital responses (e.g., LDI, thermography) are more strongly correlated with self-reported sexual arousal than is vaginal vasocongestion (e.g., Bouchard et al., 2017; Huberman & Chivers, 2015; Chapter Two; meta-analysis by Chivers, Seto, Lalumière, Laan, & Grimbos, 2010). Only a few studies have examined the cue-specificity of external genital changes in women. Suschinsky, Dawson, and Chivers (2020) and Huberman and Chivers (2015) observed low gender/sex cue-specificity for clitoral blood volume and for labial and clitoral temperature, respectively; however, low cue-

specificity was also observed for women's self-reported sexual arousal in these studies. Given that external genital changes appear to be more highly correlated with self-reported sexual arousal (Chivers et al., 2010), it would be important to examine the cue-specificity of external genital changes in response to a variety of sexual stimulus categories that elicit differentiation in self-reported sexual arousal. Indeed, genital lubrication exhibited increases only in response to stimuli that elicited the highest degrees of self-reported sexual arousal.

Measuring lubrication. A methodological factor that may have contributed to the lack of agreement between vaginal vasocongestion and lubrication in Chapter Two was that VPP assessed vasocongestion in the vaginal canal whereas LTS assessed lubrication at the introitus (i.e., vaginal opening). Wetness measured by the LTS was likely transudate from the vaginal epithelium that descended toward the introitus and some fluid may have originated from the labia minora and Bartholin's glands (Levin, 2003). Vasocongestion within the vaginal walls would not necessarily be expected to strongly relate to wetness assessed at the introitus (Dawson et al., 2015). Observational research by Masters and Johnson (Masters, 1959; Masters & Johnson, 1966) suggested that lubrication coats the vaginal epithelium within 10–30 s of sexual stimulation, but the timing of fluid descent to the introitus and external genitalia is unknown. Conceivably, the migration of lubrication would depend on the women's body positioning (due to gravity) and the amount of fluid present. It is possible that smaller increases in lubrication were elicited by the less sexually arousing stimuli in Chapter Two, but that lubrication did not sufficiently descend to be detected by the LTS. Also, the LTS may not be adequately sensitive to capture less salient differences in genital wetness.

Since the publication of Chapter Two, two studies of genital lubrication have been conducted. Bouchard et al. (2019) concurrently assessed genital blood flow and lubrication with LDI and LTS, respectively. The between-subjects correlation between vulvar blood flow and

lubrication in response to male–female intercourse was $r = .41$. This finding supports the hypothesis that the weak correlation between vaginal vasocongestion and lubrication in Chapter Two ($r = .05$) was specific to the VPP (also see Dawson et al., 2015), whereas genital changes assessed externally may be more strongly related. In another study, Handy and Meston (2019) used a modified LTS device (Schirmer tear test strips) to quantify genital lubrication at the introitus (in mm) in response to sexual stimuli in women. The within-subjects correlation between lubrication and self-reported sexual arousal in this study ($r = .41$; A. Handy, personal communication, April 2nd, 2019) was within the range of the within-subjects concordance estimates for LTS in Chapter Two ($r = .39$–$.57$). Taken together, the results from these studies further support the use of litmus or Schirmer tear test strips to quantify genital lubrication in repeated measures experiments; however, the results presented in Bouchard et al. and Chapter Two showed substantial increases in lubrication for only the most sexually arousing stimuli, suggesting that the LTS may not be sufficiently sensitive to detect smaller changes in lubrication.

A measure of intra-vaginal lubrication may demonstrate improved sensitivity to more subtle changes in lubrication and may capture a response more strongly associated with vaginal vasocongestion assessed with VPP. Using a modified LTS applicator, the litmus or Schirmer tear test strips could be encased in a non-absorbent plastic applicator (e.g., similar to a tampon applicator) with only the tip of the test strip exposed to the vaginal epithelium. Similar to the procedure outlined in Chapter Two, the applicator could be inserted vaginally for 60 s while the wetness is absorbed up the length of the test strip. As with the VPP, a placement anchor that rests against the introitus could ensure consistent and correct insertion depth. To exclusively measure lubrication within the vaginal canal, a mechanism could be included to expel the tip of the test strip only after insertion and to retract it before removal to avoid contact with vulvar and introital fluids during insertion. Developing a measure of vaginal lubrication is important to further

examine the preparation hypothesis, test the replicability of the Chapter Two results (i.e., the specificity of lubrication for preferred sexual stimuli), and enhance our understanding of the components of the female genital response. A well-tested, valid measure of genital lubrication also has clinical utility in conceptualizing sexual dysfunction (e.g., Handy & Meston, 2019) and evaluating the efficacy of pharmacological and psychological treatments for sexual difficulties (e.g., hormonal treatment for vaginal dryness; see Carranza-Lira et al., 2003; see Clinical Implications section below).

Other Methodological Considerations and Limitations

Stimuli and context. A limitation of current research on cue-specificity is that sexual responses are evoked almost exclusively by visual and/or audio inputs. These modalities are useful when examining the impact of cue variations on sexual response, but their ecological validity may be limited. Genital stimulation via a hands-free vibrator (i.e., vibrotactile stimulation) was included in one study to test the hypothesis that cue-specificity could be observed with higher levels of sexual arousal (Peterson, Janssen, & Laan, 2010). Vibrotactile stimulation with audiovisual sexual stimuli was found to elicit larger increases in vaginal vasocongestion than audiovisual stimuli alone; however, on average, patterns of gender/sex cue-specificity remained consistent across vibrotactile and non-vibrotactile conditions, and this was the case for both self-identified heterosexual and lesbian women. Examination of within-group variation revealed a more nuanced pattern of results. Across both conditions, the most elevated genital response was elicited by male–female penetrative sex for 50–60% of heterosexual women, and female–female penetrative sex for 32–48% of lesbian women. These results suggest that group-level comparisons can mask within-group variation in cue-specificity—a limitation that is discussed in the following section.

Another limitation is that stimuli include a complex amalgamation of cues, particularly for audiovisual stimuli. Manipulating one cue, such as gender/sex, inherently affects other stimulus content, such as sex acts, sexual positions, and gender roles. Scripted audio-narratives allow for greater stimulus control than commercially available films (e.g., Chivers & Timmers, 2012; Suschinsky & Lalumière, 2011a). Some authors have presented still images with reduced contextual information, which can afford greater precision or selectivity when varying a cue across stimulus presentations (e.g., Spape, Timmers, Yoon, Ponseti, & Chivers, 2014; Timmers, 2019). Cue-specificity for male stimuli has been found for androphilic women presented with still images containing minimal contextual information that depicted aroused genitals (Spape et al., 2014) and attractive and unattractive nude individuals (Timmers, 2019). As discussed by the authors of these studies, findings of low gender/sex cue-specificity among women, particularly androphilic women, may reflect a response to contextual cues (e.g., body shape, mannerisms, gender roles, sexual positions, attractiveness)—cues that are distinct yet difficult to disentwine from strictly primary and secondary sex characteristics in typical audiovisual sexual stimuli (hence why the term gender/sex is used throughout most of the dissertation).

In addition to the contextual elements within sexual stimuli in the laboratory, the physical context of the participant's environment may also impact response patterns. In one study, genital vasocongestion measured with vaginal and clitoral photoplethysmography was found to be stronger in the home environment than in the laboratory (Bloemers et al., 2010), suggesting that genital responses measured in the laboratory may be only somewhat analogous to sexual responses in more natural environments (Hatch, 1979). Portable recording methods that can be used in the home (e.g., Bloemers et al., 2010) and participant-selected sexual stimuli (e.g., participants select the most and least arousing films from specific categories within a stimulus set) may increase our understanding of the stimulus features that are most relevant to women's

genital responses and how genital responses manifests in more natural environments. Further, eliciting feedback or conducting systematic qualitative research could elucidate participants' subjective experience of sexual arousal during stimulus presentations.

Experimenter effects. For standardization purposes, the experimenters of studies in this dissertation used scripts when providing participant instructions. During testing, experimenters were in a separate room of the laboratory and communicated with participants via text messages whenever possible (alternatively, an intercom was available). Despite consistent wording of the instructions, speech characteristics (e.g., tone, intonation), nonverbal behaviour, physical appearance, affective state, and general style would have varied across experimenters, as well as within experimenters on a day-to-day basis. The influence of the experimenter is, therefore, not a constant and can introduce potential confounding effects. Pre-recorded instructions could increase standardization and participants' sense of privacy; however, this method may inhibit participants' propensity to voluntarily ask questions and impact overall comfort levels. Indeed, during oral and written debriefing, many participants positively commented on experimenters' professionalism and warmth, which was reported to increase their sense of comfort with the laboratory environment and testing procedures. Greater participant comfort could, conceivably, foster a permissive expression of sexual arousal or elicit socially desirable responding, leading to an artificial minimization or inflation of sexual responses.

There is surprisingly little empirical examination of experimenter effects in sexuality research. An incidental effect that has been investigated in nonsexual psychological and physiological research is that of experimenter gender/sex (see reviews by Chapman, Benedict, & Schiöth, 2018; Thorson, Mendes, & West, 2019). Experimenter gender/sex has been shown to bias results in studies of, for example, prosociality, aggression, pain sensitivity, and cognitive functioning (Chapman et al., 2018). Considering the cultural sensitivities around sexuality, it is

conceivable that experimenter gender/sex could affect participants' sexual arousal and behaviour (Janssen, 2002), yet only a handful of studies have been conducted in this area. Early work found that heterosexual male participants were less likely to describe sexual imagery in a thematic apperception test (TAT) following the presentation of female nude images (versus landscape images) or when the experimenter was an attractive woman (versus man; Clark, 1952). Men have also been found to report a higher number of sexual partners when primed with a fictitious statement that women are becoming more sexually permissive and experienced, but only when a female researcher administered the study questionnaires; experimenter gender/sex did not influence female participants' questionnaire responses (Fisher, 2007).

Two studies investigated the potential effect of experimenter gender/sex on sexual responses, specifically. One study examined the impact of participant gender/sex, experimenter gender/sex, and experimenter style on self-reported sexual arousal and perceived genital sensations to sexual films. Sexual response ratings did not vary by experimenter gender, but were higher for experimenters with informal (i.e., warm, personable, casual) versus formal (i.e., cool, task-oriented, objective) personality styles (Abramson, Golberb, Mosher, Abramson, & Gottesdiener, 1975). The authors speculated that informal experimenters fostered a permissive social context that resulted in less inhibition and more sexual arousal. In an unpublished study (Williams et al., 1990) cited by Janssen (2002), men's genital responses were lower for female versus male experimenters (sexual stimulus type was not reported).

There are no known published studies documenting the impact of experimenter gender/sex on female genital and self-reported sexual responses. This is perhaps owing to the fact that the overwhelming majority of sexual psychophysiological studies are conducted by female experimenters (e.g., Bouchard et al., 2019; Chivers et al., 2007; Suschinsky et al., 2009; Chapters Two–Five). A priming effect of the experimenters' gender/sex (or other personality and

physical attributes) could impact sexual response patterns. If a female experimenter primes sexual responses to female sexual cues, especially for gynephilic women, this could account for the observed sexual orientation difference in gender/sex cue-specificity among women—a hypothesis that could be empirically examined.

Aggregate data. Another methodological consideration in the study of cue-specificity is that results are based on aggregate data. As discussed by Lalumière et al. (2020), low cue-specificity may not represent the response profile of individual women, but may be an artifact of averaging heterogeneous response patterns in women. For gender/sex cues, for example, if half of women respond more to male sexual stimuli and half respond more to female sexual stimuli, the average of women's responses would show no discrimination between stimulus categories. If low cue-specificity for genital response in women is indeed a product of averaging data, then explaining the gender/sex difference in response pattern heterogeneity is a more appropriate area of inquiry (Lalumière et al., 2020). There is some evidence already that women's sexual responses are heterogeneous in the degree of discrimination and the direction of stimulus preference, and that this heterogeneity is masked by aggregate low cue-specificity (see viewing time study by Lalumière, Babchishin, & Ebsworth, 2018). To date, there have been limited attempts to examine individual differences in patterns of genital response cue-specificity (for exceptions see Peterson et al., 2010; Pulverman, Hixon, & Meston, 2015).

While not a direct focus of this dissertation, some attempts were made to address or report on individual data. In Chapter Two, some of the analyses were performed according to stimulus preference rankings, which were determined at the individual level. On average, lubrication, but not vaginal vasocongestion, demonstrated specificity for participants' 1st and 2nd most preferred stimulus category, with preferences based on individual self-reported sexual arousal ratings. In Chapter Three, the indices of cue-specificity were calculated separately for each participant.

Doing so took into account individual variability in the stimulus category that elicited the largest increase in vaginal vasocongestion (stimulus index) or that was subjectively the most sexually arousing (preference index). In Chapter 5, the percentage of women and men whose APA was most elevated in response to a sexual stimulus category was reported. Doing so showed that although the effect of sexual stimulation on APG responses was, on average, lower for men than women, the majority of men and women produced their most elevated response to a sexual category, suggesting that the APG may have detected a sexual response, to some extent, in most participants.

For the purpose of examining Lalumière et al.'s (2020) hypothesis regarding aggregate effects, a subsidiary analysis was performed for this General Discussion using Chapter Two data, in order to determine the proportion of women who demonstrated genital response specificity for preferred stimulus categories; that is, the proportion of women whose greatest genital response was represented within the 1st or 2nd most preferred categories. Cut-offs for determining specificity have not been established within the literature (Chivers, 2017; Lalumière, 2017); in Peterson et al. (2010) and in Chapter Three (stimulus index), for example, a relatively higher response by any margin was considered to be specific. In Table 6.1, the proportion of women who demonstrated specificity for preferred stimulus categories (either 1st or 2nd most preferred) are presented, with specificity defined according to three different criteria: greatest response to a preferred category by any margin; greatest response to a preferred category by greater than 0.5 standard deviations (*SD*s); or greatest response to a preferred category by greater than 1 *SD* (*SDs* were calculated within-subjects). For the latter two criteria, if a woman's most elevated response was to her 1st or 2nd most preferred category, but was not either >0.5 *SD* or >1 *SD* higher than to her less preferred categories, the response was not considered cue-specific. Simple comparisons based on proportions show that for vaginal vasocongestion, a number of women demonstrated

specificity for preferred stimuli even though group-based analyses in Chapter Two showed a similar degree of vaginal vasocongestion across rank-preferred categories. More women seemed to show cue-specificity for lubrication compared to vaginal vasocongestion. It should be noted, however, that using within-subjects standard deviation criteria could reveal cue-specificity even with very small differences in responses to sexual stimuli.

Individual variation was also examined for this General Discussion using the stimulus index from Chapter Three (i.e., the difference between the VPP response to the stimulus that elicited the greatest response and the average of responses to the other sexual stimuli). Figure 6.1 presents each woman's stimulus index value for each time epoch, as well as the linear trend for each woman. Examination of Figure 6.1 shows variability in the linear trend line slopes: For most women the linear trend lines increased minimally, but for some women the trend lines increased more dramatically meaning that cue-specificity increased across stimulus duration for some women.

Results presented in Chapter Three showed that, on average, there was no linear increase in the stimulus index after 60 s and 90 s. Here, change in the stimulus index after 60 s and after 90 s was examined individually. The stimulus index at the final epoch was greater than that at the 61–75 s epoch by 0.5 *SD* for 44% of women and 1 *SD* for 33% of women (*SD* were calculated within-subject). Compared to the 91–105 s epoch, the stimulus index at the final epoch was greater by 0.5 *SD* for 39% of women and 1 *SD* for 28% of women. These results demonstrate that the stimulus index increased by at least 0.5 *SD* after 60 s for a sizable proportion of women. More sophisticated multivariate analytic techniques, such as multilevel modeling (MLM) would allow for most robust statistical investigation of individual variations in cue-specificity, as well as predictors of the response patterns (e.g., Huberman, Dawson, & Chivers, 2017; Pulverman et al., 2015). MLM was not used in this dissertation because the interpretation of its results is

largely dependent on *p*-values. The research here did not use null hypothesis significant testing in light of the compeling arguments against reporting and interpretating *p*-values (e.g., Cumming, 2012; Kline, 2014). The shortcomings of the R-squared effect size that is often reported with MLM are outlined in a recent article by Rights and Sterba (2019). The authors discuss the lack of a consistent approach to interpreting R-squared and note the absence of a reliable method to obtain standard errors or confidence intervals at this time.

Implications for the Preparation Hypothesis

If cue-specificity were replicated for vaginal lubrication and not vaginal vasocongestion, the preparation hypothesis would require abandonment or revision. If nonpreferred or less sexually arousing stimuli do not produce a lubrication response (as demonstrated in Chapter Two), this suggests that lubrication occurs only under certain circumstances. The formation of lubrication may depend on its precursor, vaginal vasocongestion, to automatically respond to a wide range of sexual cues, thereby initiating or activating the genital response system. In this sense, the automatic activation of vaginal vasocongestion may be protective because it readies the body for a potential proliferation of genital response. Consistent with the IPM of sexual response (Geer et al., 1993; Janssen et al., 2000), vaginal vasocongestion may be an automatic process akin to an "on/off switch" that is reflectively activated by the automatic appraisal of any sexual cue and that reaches maximal responding within 60–90 s (at least for audiovisual sexual stimuli, consistent with the results of Chapter Three). Janssen et al. (2002) suggested that the initial automatic processing stage involves the priming of the genital response system. Research by Huberman et al. (2017) on the time course of sexual responses supports the idea that the automatic activation of vaginal vasocongestion occurs prior to other genital changes (e.g., clitoral temperature) and the conscious evaluation of the appeal of the sexual cue (e.g., self-reported sexual arousal).

Unlike the automatic activation of vaginal vasocongestion, the time course of genital lubrication may be relatively longer, involving the subsequent controlled cognitive pathway of the IPM in which more elaborative processing occurs (Geer et al., 1993; Janssen et al., 2000). As previously discussed, when cognitive elaboration results in positive or rewarding associations, feelings of sexual arousal and desire increase, and a full-blown genital response occurs. At the subsequent controlled (conscious) processing stage, feelings of sexual arousal, awareness of genital sensations, and physiological responses are thought to be reciprocally reinforcing. Consistent with the IPM, conditions under which genital responses proliferate and lubrication is produced could include highly anticipated sexual activity, triggered by viewing sexual stimuli associated with positive sexual meanings in memory that elicit strong feelings of sexual arousal. In Chapter Two, the sexual category that elicited the highest degree of self-reported sexual arousal and genital lubrication for the androphilic women (on average) was male–female sex—the stimulus category that, based on reported gender/sex attractions, may have triggered heightened sexual anticipation and sexual meanings in memory.

In addition to increases in lubrication, the proliferation of genital responses may include external genital changes. Research on the time course of different components of genital responding is consistent with the idea that genital changes occur in stages. Increases in clitoral blood volume (Gerritsen et al., 2009) and labial temperature (Huberman & Chivers, 2015; Huberman et al., 2017) occur more slowly than increases in vaginal vasocongestion. Different branches of the internal iliac artery supply the external genitalia (internal pudendal artery) and vagina (middle rectal artery; Moore, Dalley & Argur, 2013); therefore, it is anatomically possible that blood flow to the external genitalia is distinct from, yet related to, vaginal blood flow. Associations among later-stage proliferation responses may be stronger relative to their associations with the initial activation response (i.e., vaginal vasocongestion). Indeed, lubrication

and vulvar blood flow are more strongly related than lubrication and vaginal vasocongestion (Bouchard et al., 2019; Dawson et al., 2015; Sawatsky et al., 2018). Generally, external genital responses are also more strongly related to self-reported sexual arousal than is vaginal vasocongestion (e.g., Bouchard et al., 2017; Dawson et al., 2015; meta-analysis by Chivers et al., 2010), supporting the idea that proliferation responses are associated with the controlled cognitive processing stage of the IPM.

Another condition under which genital responses proliferate could include the actual experience of sexual activity, regardless of the presence of experienced sexual arousal, which is consistent with the preparation hypothesis (Suschinsky & Lalumière, 2011a, 2011b). Given the protective benefits of such a response (see Lalumière et al., 2020), the formation of lubrication during the actual experience of sexual activity may be less dependent on the controlled processing stage of the IPM relative to visual or imagined sexual cues. Proprioceptive sexual cues during the actual experience of sexual activity may be more biologically relevant; therefore, at a proximate level, proprioceptive sexual cues may have different impacts on the sympathetic and parasympathetic nervous systems, biochemical responses (e.g., hormones, neurotransmitters), and neural activation than exclusively visual or imagined sexual cues. There is evidence that biologically relevant visual stimuli associated with reproduction and survival motivations induce automatic attention and emotional reactions, whereas non-biologically relevant social stimuli require more elaborative processing (e.g., Sakaki. Niki, & Mather, 2012).

To test this *activation-proliferation hypothesis* of genital response and to elucidate the conditions under which downstream aspects of genital responding (e.g., lubrication) occur, sexual stimuli that evoke different degrees of self-reported sexual arousal could be presented during a genital stimulation condition (e.g., self or vibratory stimulation; Henson, Rubin, & Henson, 1982; Peterson et al., 2010; Prause, Roberts, Legarretta, & Rigney Cox, 2012). Using a

within-subjects design, women could be presented with the same stimulus categories in two conditions—genital stimulation and non-stimulation. It is possible that direct mechanical stimulation (i.e., manual, oral, genital) of the genitals, even in the absence of self-reported feelings of sexual arousal, is a more potent sexual cue that supersedes audio and/or visual sexual cues and stimulates a lubrication response. This hypothesis would be supported if genital lubrication were produced in response to nonpreferred stimuli in only the genital stimulation condition. Although Peterson et al. (2010) did not observe an effect of genital stimulation on patterns of cue-specificity for vaginal vasocongestion (on a group level), this finding may not translate to genital lubrication given the weak association between these physiological processes (Dawson et al., 2015; Chapter Two).

Concurrent assessment of visual attention and genital responses would elucidate whether differences in the cognitive processing of sexual stimuli influence patterns of genital responses. Research on visual attention supports the idea that different stages of information processing elicit different patterns of response to sexual stimuli. Using eye-tracking to examine gender/sex-specificity for visual attention to sexual still images, Dawson and Chivers (2016, 2018, 2019) found that androphilic women's initial attentional processing demonstrated low gender/sex cue-specificity, whereas subsequent controlled attentional processing was biased towards male images. Self-reported attraction to sexual stimuli was positively associated with attentional processing and, consistent with the IPM (Geer et al., 1993; Janssen et al., 2000), the effect was stronger for controlled attention (Dawson & Chivers, 2018, 2019). Interestingly, gender/sex-specificity for controlled attention was only observed in response to sexual still images, not sexual films (Dawson & Chivers, 2019). These results are consistent with studies of genital response that have observed gender/sex cue-specificity when androphilic women were presented with sexual still images (Spape et al., 2014; Timmers, 2019), but not when presented with more

complex audiovisual or audio-narrative sexual stimuli (e.g., Chivers & Timmers, 2012; Chivers et al., 2007).

Dawson and Chivers (2019) examined gender/sex-specificity by comparing visual attention to male and female sexual targets; visual attention patterns were not compared across male–male, female–female, and male–female sexual stimuli. In Chapter Two, it is possible that controlled visual attention was captured and maintained by sexual cues more for the male–female sexual stimuli, and that androphilic women spent more time attending to the nonsexual contextual features (e.g., background) for the less sexually arousing male–male and female–female stimuli. Within the emotion literature more broadly, highly arousing stimuli recruit more attention and enhance cognitive processing relative to less salient stimuli (Sakaki et al., 2012). Patterns of automatic and controlled visual attention for preferred and nonpreferred sexual stimuli may be a proximate mechanism that explains the varying patterns of genital response to different categories of sexual stimuli.

Activation-proliferation in men. A benefit of studying the cue-specificity of internal physiological sexual changes in men using, for example, dynamic MRI or APG (if validated for men) is that physiological responses apart from penile erection can be assessed. The cue-specificity of the male genital responses has been assessed almost exclusively by penile tumescence, which is an obvious indicator of sexual response that provides visual and tactile feedback (unlike vaginal vasocongestion). It is possible that men also experience an initial increase in pelvic vasocongestion that activates the sexual response system. The initial activation response in men may be quick and indiscriminate, akin to vaginal vasocongestion in women. A full genital response (i.e., penile erection) may proliferate in response to only specific sexual cues, such as those that correspond with sexual preferences or that elicit strong feelings of sexual arousal. As was proposed here for women, the male genital response may also proliferate during

the actual experience of sexual activity, even in the absence of feelings of sexual arousal. There is evidence that both men (Bullock & Beckson, 2011) and women (Levin & van Berlo, 2004) exhibit genital responses and/or orgasm during nonconsensual sex.

Consistent with the activation-proliferation hypothesis, a proliferation of male genital response would occur more slowly and would be more highly related to self-reported sexual arousal. Indeed, there is evidence that peak penile erection is reached much more slowly (229 s) than peak vaginal vasocongestion (21 s; Huberman et al., 2017; also see the time course of change in VPP and PPG responses in Chapter Three). Also, penile tumescence assessed with PPG consistently demonstrates strong positive correlations with self-reported sexual arousal (meta-analysis by Chivers et al., 2010). Use of dynamic MRI and APG (if validated in men) to assess and compare initial- and later-stage sexual responses within the genital and pelvic region may elucidate whether or not men also experience an initial physiological response that is comparable to vaginal vasocongestion and to examine the cue-specificity of this response.

If men were found to exhibit an initial indiscriminate physiological response (e.g., increase in pelvic vasocongestion) to any sexual stimuli, then patterns of male and female sexual response may be similar, but the function of the initial automatic response may be different. A rapid, automatic activation response may serve a protective function for women by readying the body for a potential proliferation of genital response, including lubrication. For men, the activation response may function to ready men for potential sexual opportunities. According to Trivers' (1972) parental investment theory, men can maximize reproductive fitness by increasing the quantity of sexual partners and outcompeting other men for relatively limited mating opportunities (whereas women benefit from a more judicious mate selection strategy due to high parental investment). It may, therefore, be adaptive for men to automatically produce an internal activation response that readies the body for a potential proliferation of genital response.

Clinical Implications

As discussed, the observed gender/sex differences in cue-specificity have been of empirical and theoretical interest (e.g., reviews by Chivers, 2017; Lalumière et al., 2020) and elucidating the source of the discrepancy has been an impetus for methodological development and validation (e.g., Dawson et al., 2015; Suschinsky et al., 2009; Chapters Two and Five). Understanding patterns of genital response also has clinical relevance. With respect to the preparation hypothesis, for example, providing psychoeducation about the automaticity of genital response in women may be of therapeutic value for victims of nonconsensual sex (Chivers, 2005; Suschinsky, 2012). Based on anecdotal evidence from my clinical practice, awareness of the protective function of automatic genital responding can provide comfort to women who otherwise feel betrayed by or disconnected from their bodies as a result of having experienced a genital response during nonconsensual sex. It would be worthwhile to conduct clinical outcome research on the potential therapeutic benefits (e.g., mental health, sexual functioning) of psychoeducation about the protective function of automatic genital responses in women (and potentially the automatic readiness function for men).

The establishment of valid, reliable instruments to measure genital responses has utility in the conceptualisation of sexual dysfunctions and its assessment, diagnosis, and treatment. Results from psychophysiological studies investigating the genital responsivity of women presenting with sexual difficulties are inconsistent and may be influenced by the measurement device, the physiological process assessed, and the type of sexual difficulty or clinical presentation. Using LDI to assess vulvar blood flow showed that, women with provoked vestibulodynia demonstrated lower genital responses to audiovisual sexual stimuli compared to non-affected women (Boyer, Pukall, & Chamberlain, 2013). Many other instruments, however, show similarity in the genital responses of women with and without sexual difficulties. Cherner

and Reissing (2013) compared women with lifelong vaginismus, lifelong dyspareunia, and women with no pain or penetration-related difficulties, and observed similar elevations in vulvar temperature assessed with thermography. In another study, genital temperature did not differentiate between women diagnosed with hypoactive sexual desire disorder or female sexual arousal disorder, and non-affected women (Sarin, Amsel, & Binik, 2016). VPP also does not reliably differentiate between women with and without sexual difficulties (e.g., Brauer, Laan, & ter Kuile, 2006; Laan, van Driel, & van Lunsen, 2008; Meston, Rellini, & McCall, 2010). In recent research, the degree of genital lubrication did not differentiate between women with and without symptoms of female sexual arousal disorder when lubrication was measured with an LTS-like device (Handy & Meston, 2019).

Results showing no reliable differences in the genital responsivity of women with and without sexual difficulties suggest that other aspects of women's sexuality are relevant to sexual function and dysfunction. Indeed, it has been noted that an overreliance on genital responses in the conceptualisation and diagnosis of sexual difficulties risks neglecting other important aspects, namely the woman's experience of sexual arousal and associated distress, and her sexual context (e.g., situational or relationship factors; e.g., Basson et al., 2003; Brotto, Bitzer, Laan, Leiblum, & Luria, 2010). According to Basson et al.'s (2003) subtypes of female sexual disorders, absent or impaired genital responses represent only one subtype, with other subtypes pertaining to difficulties with sexual interest or feelings of sexual arousal. Basson et al. also point out that not all women report distress related to sexual difficulties. To illustrate, Shifren, Monz, Russo, and Segreti (2008) found that the prevalence of self-reported sexual difficulties in women was 40% in a United States nationally representative sample, but that the prevalence of sexual difficulties with associated distress was only 12%. Understanding the determinants of typical sexual functioning and sexual difficulties in women is important to the formulation of

appropriate, female-specific diagnostic criteria (e.g., Brotto, 2010), which guide effective clinical interventions (reviewed by Chivers & Brotto, 2017). Validated measures of the physiological changes that comprise the female genital response facilitate greater understanding of women's sexualities. If there are no reliable differences in the degree of genital vasocongestion or lubrication between women with and without sexual difficulties, this underscores the importance of non-genital factors (e.g., mental sexual arousal, awareness of genital response, adequate stimulation) in the manifestation and treatment of sexual concerns in women (see Brotto, 2018).

Accurate knowledge and understanding of the determinants of sexual arousal is also relevant to the development of models of sexual response. Models provide a theoretical anchor to understand sexual response patterns observed in the laboratory. For instance, according to Basson (2000, 2001), nonsexual rewards and outcomes (e.g., emotional closeness) and situational factors (e.g., emotional and physical safety) are especially relevant to women's sexual functioning. In fact, Basson argued that nonsexual rewards might be more relevant to women's sexual motivation and arousal than the sexual stimulus itself. In the laboratory setting, the importance of nonsexual rewards and situational factors for women may manifest as greater variability in genital response magnitude to contextual cues versus more overt sexual cues associated with gender/sex. The absence of sexual and nonsexual rewards in laboratory settings (e.g., emotional intimacy, stress relief, sexual release) may also contribute to low concordance between experienced sexual arousal and genital responses in women. Low concordance is also consistent with the cyclical nature of the Basson model: Unlike the traditional Masters and Johnson (1966) linear model of sexual response, the Basson model has no fixed start- and end-points, meaning that the physiological and emotional aspects of sexual arousal are not necessarily expected to act in unison. The development of models of sexual response that are based on empirical evidence and that consider the uniqueness of women's sexuality is imperative

for conceptualizing typical sexual functioning, as well as diagnosing and treating sexual difficulties (see Chivers & Brotto, 2017).

Sexual health can be further promoted by imparting knowledge through education within medical, therapeutic, and institutional settings. For instance, university undergraduate courses in human sexuality can be an opportunity to facilitate the development of knowledge and attitudes, and self-awareness that support sexual health and wellbeing. For this reason, professors are encouraged to teach beyond the traditional Masters and Johnson (1966) model of sexual response and to include more contemporary models that consider the unique aspects of male and female sexuality, such as the Basson model (2000, 2001).

Conclusion

Advances in the laboratory-based assessment of sexual responses have given way to a proliferation of research focussed on testing models and explanations of sexual response patterns. Research presented in this dissertation and elsewhere suggests that some of the observed gender/sex differences in genital response patterns may be attributed to methodological issues, thus prompting a reconsideration of previously held inferences regarding women's sexual responses. Women's genital responses were once reported to be nonspecific and discordant, but these conceptions and terminologies now seem to be overly simplistic in light of evidence showing that different components of the female genital response show different degrees of cue-specificity and sexual concordance. Moving forward, the integration of multiple measurement devices and methodologies, as well as analytical approaches that take into account individual variation, will provide a more comprehensive understanding of the dynamic and multidimensional nature of sexual responses. Consideration of the limitations and advantages of the various methodological approaches will determine their suitability for addressing particular research or clinical questions. Elucidating the characteristics of genital responses and their

association with sexual interests and preferences sets a foundation for quality research and effective clinical practices.

References

Abramson, P. R., Golberg, P. A., Mosher, D. L., Abramson, L. M., & Gottesdiener, M. (1975). Experimenter effects on responses to explicitly sexual stimuli. *Journal of Research in Personality, 9*, 136–146.

Basson, R. (2000). The female sexual response: A different model. *Journal of Sex & Martial Therapy, 26*, 51–65. doi:10.1080/009262300278641

Basson, R. (2001). Using a different model for female sexual response to address women's problematic low sexual desire. *Journal of Sex & Marital Therapy, 27*, 395–403.

Basson, R., Leiblum, S., Brotto, L., Derogatis, L., Fourcroy, J., Fugl-Meyer, K., . . . Schultz, W. W. (2003). Definitions of women's sexual dysfunction reconsidered: Advocating expansion and revision. *Journal of Psychosomatic Obstetrics & Gynecology, 24*, 221–229. doi:10.3109/01674820309074686

Baumeister, R. F. (2000). Gender differences in erotic plasticity: The female sex drive as socially flexible and responsive. *Psychological Bulletin, 126*, 347–374. doi:10.1037//0033-2909.126.3.347

Bloemers, J., Gerritsen, J., Bults, R., Koppeschaar, H., Everaerd, W., Olivier, B., & Tuiten, A. (2010). Induction of sexual arousal in women under conditions of institutional and ambulatory laboratory circumstances: A comparative study. *Journal of Sexual Medicine, 7*, 1160–1176. doi:10.1111/j.1743-6109.2009.01660.x

Bohlen, J. G., & Held, J. P. (1979). An anal probe for monitoring vascular and muscular events during sexual response. *Instrumentation, 16*, 318–324.

Bossio, J. A., Singh, M., & Pukall, C. F. (2018). Concurrent assessment of penile blood flow and circumference as indicators of male sexual arousal. *The Journal of Sexual Medicine, 15*, 1570–1578. doi:10.1016/j.jsxm.2018.08.016

Bouchard, K. N., Chivers, M. L., & Pukall, C. F. (2017). Effects of genital response measurement device and stimulus characteristics on sexual concordance in women. *The Journal of Sex Research, 54*, 1197–1208. doi:10.1080/00224499.2016.1265641

Bouchard, K. N., Dawson, S. J., Shelley, A. J., & Pukall, C. F. (2019). Concurrent measurement of genital lubrication and blood flow during sexual arousal. *Biological Psychology, 145*, 159–166. doi:10.1016/j.biopsycho.2019.05.003

Bouchard, K. N., Timmers, A. D., & Chivers, M. L. (2015). Gender-specificity of genital response and self-reported sexual arousal in women endorsing facets of bisexuality. *Journal of Bisexuality*, *15*, 180–203. doi:10.1080/15299716.2015.1022924

Boyer, S. C., Bouchard, K. N., & Pukall, C. F. (2019). Laser Doppler imaging as a measure of female sexual arousal: Further validation and methodological considerations. *Biological Psychology, 148*, 107741. doi:10.1016/j.biopsycho.2019.107741

Boyer, S. C., Pukall, C. F., & Chamberlain, S. M. (2013). Sexual arousal in women with provoked vestibulodynia: The application of laser Doppler imaging to sexual pain. *The Journal of Sexual Medicine, 10*, 1052–1064. doi:10.1111/j.1743-6109.2012.02855.x

Brauer, M., Laan, E., & ter Kuile, M. M. (2006). Sexual arousal in women with superficial dyspareunia. *Archives of Sexual Behavior*, *35*, 191–200. doi:10.1007/s10508-005-9001-7

Brotto, L. A. (2010). The DSM diagnostic criteria for hypoactive sexual desire disorder in women. *Archives of Sexual Behavior, 39*, 221-239. doi:10.1007/s10508-009-9543-1

Brotto, L. A. (2018). Better Sex Through Mindfulness: How women can cultivate desire. Vancouver, Canada: Greystone Publishing.

Brotto, L. A., Bitzer, J., Laan, E., Leiblum, S., & Luria, M. (2010). Women's sexual desire and arousal disorders. *Journal of Sexual Medicine, 7*, 586–614. doi:10.1111/j.1743-6109.2009.01630.x

Bullock, C. M., & Beckson, M. (2011). Male victims of sexual assault: Phenomenology, psychology, physiology. *The Journal of the American Academy of Psychiatry and the Law, 39*, 197-205.

Carmichael, M. S., Humbert, R., Dixen, J., Palmisano, G., Greenleaf, W., & Davidson, J. M. (1987). Plasma oxytocin increases in the human sexual response. *The Journal of Clinical Endocrinology, 64*, 27–31.

Carmichael, M. S., Warburton, V. L., Dixen, J., & Davidson, J. M. (1994). Relationships among cardiovascular, muscular, and oxytocin responses during human sexual activity. *Archives of Sexual Behavior*, *23*, 59–79.

Carranza-Lira, S., Fragoso-Díaz, N., MacGregor-Gooch, A. L., Garduño-Hernández, M. P., Ríos-Calderón, K., & Aparicio, H. (2003). Vaginal dryness assessment in postmenopausal women using pH test strip. *Maturitas, 45*, 55–58. doi:10.1016/s0378-5122(03)00082-3

Carrito, M. L., Tavares, I. M., Pereira, R., & Nobre, P. J. (2019, October). *Cleaning procedures of genital measures in Sexlabs: Current practices and emerging challenges*. Proceedings of the 24th Congress of the World Association for Sexual Health, Mexico City, Mexico.

Chapman, C. D., Benedict, C., & Schlöth, H. B. (2018). Experimenter gender and replicability in science. *Science Advances, 4*, e1701427.

Chivers, M. L. (2005). A brief review and discussion of sex differences in the specificity of sexual arousal. *Sexual and Relationship Therapy*, *20*, 377–390. doi:10.1080/14681990500– 238802

Chivers, M. L. (2017). The specificity of women's sexual response and its relationship with sexual orientations: A review and ten hypotheses. *Archives of Sexual Behavior, 46*, 1161–1179. doi:10.1007/s10508-016-0897-x

Chivers, M. L., & Bailey, J. M. (2005). A sex difference in features that elicit genital response. *Biological Psychology, 70*, 115–120. doi:10.1016/j.biopsycho.2004.12.002

Chivers, M. L., Bouchard, K. N., & Timmers, A. D. (2015). Straight but not narrow; Within-gender variation in the gender-specificity of women's sexual response. *PLoS ONE, 10*(12), e0142575. doi:10.1371/journal.pone.0142575

Chivers, M. L., & Brotto, L. A. (2017). Controversies of women's sexual arousal and desire. *European Psychologist, 22*, 5–26. doi:10.1027/1016-9040/a000274

Chivers, M. L., Rieger, G., Latty, E., & Bailey, J. M. (2004). A sex difference in the specificity of sexual arousal. *Psychological Science, 15*, 736–744. doi:10.1111/j.09567976.2004.00-750.x

Chivers, M. L., Roy, C., Grimbos, T., Cantor, J. M., & Seto, M. C. (2014). Specificity of sexual arousal for sexual activities in men and women with conventional and masochistic sexual interests. *Archives of Sexual Behavior, 43*, 931–940. doi:10.1007/s10508-013-0174-1

Chivers, M. L., Seto, M. C., Lalumière, M. L., Laan, E., & Grimbos, T. (2010). Agreement of self-reported and genital measures of sexual arousal in men and women: A meta-analysis. *Archives of Sexual Behavior, 39*, 5–56. doi:10.1007/s10508-009-9556-9

Chivers, M. L., Suschinsky, K. D., Timmers, A. D., & Bossio, J. A. (2014). Experimental, neuroimaging, and psychophysiological methods in sexuality research. In D. L. Tolman, L. M. Diamond, J. A. Bauermeister, W. H. George, J. G. Pfaus & L. M. Ward (Eds.), *APA handbook of sexuality and psychology* (Vol. 1, pp. 99–119). Washington, DC: American Psychological Association

Chivers, M. L., & Timmers, A. D. (2012). Effects of gender and relationship context in audio narratives on genital and subjective sexual response in heterosexual women and men. *Archives of Sexual Behavior, 41*, 185–197. doi:10.1007/s10508-012-9937-3

Clark, R. A. (1952). The projective measurement of experimentally induced levels of sexual motivation. *Journal of Experimental Psychology, 44*, 391–399.

Cumming, G. (2012). *Understanding the new statistics: Effect sizes, confidence intervals and meta-analysis*. New York, NY: Taylor and Francis.

Dawson, S. J., Sawatsky, M. L., & Lalumière, M. L. (2015). Assessment of introital lubrication. *Archives of Sexual Behavior, 44*, 1527–1535. doi:10.1007/s10508-015-0519-z

Dawson, S. J., & Chivers, M. L. (2016). Gender-specificity of initial and controlled visual attention to sexual stimuli in androphilic women and gynephilic men. *PLoS ONE, 11*(5), e0155651. doi:10.1371/journal.pone.0152785

Dawson, S. J., & Chivers, M. L. (2018). The effect of static versus dynamic stimuli on visual processing of sexual cues in androphilic women and gynephilic men. *Royal Society Open Science, 5*, 172286. doi:10.1098/rsos.172286

Dawson, S. J., & Chivers, M. L. (2019). The effect of task demands on gender-specificity of visual attention biases in androphilic women and gynephilic men. *Personality and Individual Differences, 146*, 120–126. doi:10.1016/j.paid.2019.04.006

Diamond, L. M. (2017). Wanting women: Sex, gender, and the specificity of sexual arousal [Commentary]. *Archives of Sexual Behavior, 46*, 1181-1185. doi:10.1007/s10508-017-0967-8

Diamond, L. M., Dickenson, J. A., & Blair, K. L. (2017). Stability of sexual attractions across different timescales: The roles of bisexuality and gender. *Archives of Sexual Behavior, 46*, 193-204. doi:10.1007/s10508-016-0860-x

Fisher, T. D. (2007). Sex of experimenter and social norm effects on reports of sexual behavior in young men and women. *Archives of Sexual Behavior, 36*, 89–100. doi:10.1007/s10508-006-9094-7

Geer, J. H., Lapour, K. J., & Jackson, S. R. T. (1993). The information processing approach to human sexuality. In A. O. N. Birbaumer (Ed.), *The structure of emotion: Psychophysiological, cognitive, and clinical aspects* (pp. 139–155). Kirkland, WA: Hogrefe & Huber Publishers.

Gerritsen, J., van der Made, F., Bloemers, J., van Ham, D., Kleiverda, G., Everaerd, W., . . . Tuiten, A. (2009). The clitoral photoplethysmograph: A new way of assessing genital arousal in women. *Journal of Sexual Medicine, 6*, 1678–1687. doi:10.1111/j.1743-6109.2009.01228.x

Graziottin, A., & Gambini, D. (2015). Anatomy and physiology of genital organs – women. *Handbook of Clinical Neurology, 130*, 39–60. doi:10.1016/b978-0-444-63247-0.00004-3

Handy, A. B., & Meston, C. M. (2019). A novel technique for measuring lubrication. Manuscript submitted for publication.

Hatch, J. P. (1979). Vaginal photoplethysmography: Methodological considerations. *Archives of Sexual Behavior, 8*, 357-374.

Huberman, J. S., & Chivers, M. L. (2015). Examining gender-specificity of sexual response with concurrent thermography and plethysmography. *Psychophysiology, 52*, 1382–1395. doi:10.1111/psyp.12466

Huberman, J. S., Dawson, S. J., & Chivers, M. L. (2017). Examining the time course of genital and subjective sexual responses in women and men with concurrent plethysmography and thermography. *Biological Psychology, 129*, 359–369. doi:10.1016/j.biopsycho.2017.09.006

Janssen, E. (2002). Psychophysiological measurement of sexual arousal. In M. W. Wiederman & B. E. Whitley (Eds.), *Handbook for conducting research on human sexuality* (pp. 139–171). Mahwah, NJ: Erlbaum.

Janssen, E., Everaerd, W., Spiering, M., & Janssen, J. (2000). Automatic processes and the appraisal of sexual stimuli: Toward an information processing model of sexual arousal. *Journal of Sex Research, 37,* 8–23. doi:10.1080/00224490009552016

Kline, R. B. (2013). *Beyond significance testing: Reforming data analysis methods in behavioral research*. Washington, DC: Amercian Psychological Association.

Kukkonen, T. M. (2014). What is the best method of measuring the physiology of female sexual arousal? *Current Sexual Health Reports, 6,* 30–37. doi:10.1007/s11930-013-0010-6

Kukkonen, T. M. (2015). Devices and methods to measure female sexual arousal. *Sexual Medicine Reviews, 3,* 225–244. doi:10.1002/smrj.58

Laan, E. (1994). *Determinants of sexual arousal in women.* (Doctoral Degree), University of Amsterdam, Amersterdam, The Netherlands.

Laan, E., Everaerd, W., & Evers, A. (1995). Assessment of female sexual arousal: Response specificity and construct validity. *Psychophysiology, 32,* 476–485.

Laan, E., & Janssen, E. (2007). How do men and women feel? Determinants of subjective experience of sexual arousal. In E. Janssen (Ed.), *The psychophysiology of sex* (pp. 278–290). Bloomington, IN: Indiana University Press.

Laan E., van Driel, E. M., & van Lunsen, R. H. W. (2008). Genital responsiveness in healthy women with and without sexual arousal disorder. *Journal of Sexual Medicine, 5,* 1424–1435. doi:10.1111/j.1743-6109.2008.00827.x

Lalumière, M. L. (2017). On the concept of category-specificity [Commentary]. *Archives of Sexual Behavior, 46,* 1187–1190. doi:10.1007/s10508-017-0965-x

Lalumière, M. L., Babchishin, K. M., & Ebsworth, M. (2018). The use of film clips in a viewing time task of sexual interests. *Archives of Sexual Behavior, 47,* 627–635. doi:10.1007/s10508-017-1108-0

Lalumière, M. L., Sawatsky, M. L., Dawson, S. J., & Suschinsky, K. D. (2020). The empirical status of preparation hypothesis: Explicating women's genital responses to sexual stimuli in the laboratory. *Archives of Sexual Behavior.* Advanced online publication. doi:10.1007/s10508-019-01599-5

Levin, R. J. (2003). The ins and outs of vaginal lubrication. *Sexual and Relationship Therapy, 18,* 509–513. doi:10.1080/14681990310001609859

Levin, R. J., & van Berlo, W. (2004). Sexual arousal and orgasm in subjects who experience forced or non-consensual sexual stimulation – a review. *Journal of Clinical Forensic Medicine, 11,* 82–88. doi:10.1016/j.jcfm.2003.10.008

Maravilla, K. R., Cao, Y., Heiman, J. R., Yang, C., Garland, P. A., Peterson, B. T., & Carter, W. O. (2005). Noncontrast dynamic magnetic resonance imaging for quantitative assessment of female sexual arousal. *Journal of Urology, 173,* 162–166. doi:10.1097/01.ju.0000146643.00140.e3

Maravilla, K. R., & Yang, C. C. (2008). Magnetic resonance imaging and the female sexual response: Overview of techniques, results, and future directions. *The Journal of Sexual Medicine, 5,* 1559–1571. doi:10.1111/j.1743-6109.2008.00839.x

Masters, W. H. (1959). The sexual response cycle of the human female: Vaginal lubrication. *Annals New York Academy of Sciences, 83,* 301–317.

Masters, W. H., & Johnson, V. E. (1966). The vagina. In *The human sexual response* (pp. 68–100). Bronx, NY: Ishi Press International.

Meston, C. M., Rellini, A. H., & McCall, K. (2010). The sensitivity of continuous laboratory measures of physiological and subjective sexual arousal for diagnosing women with Sexual Arousal Disorder. *Journal of Sexual Medicine, 7,* 938–950. doi: 10.1111/j.1743-6109.2009.01548.x.

Min, K., Munarriz, R., Yerxa, B. R., Goldstein, I., Shaver, S. R., Cowlen, M. S., & Traish, A. M. (2007). Selective $P2Y_2$ receptor agonists stimulate vaginal moisture in ovariectomized rabbits. *Fertility and Sterility, 79*, 393–398.

Murad-Regadas, S. M., Regadas, F. S. P., Dealcanfreitas, I. D., Regadas Filho, F. S. P., Fernandes, G. O. d. S., Albuquerque, M. C. F., . . . Regadas, M. M. (2018). Establishing the normal ranges of female and male anal canal and rectal wall vascularity with color Doppler anorectal ultrasonography. *Journal of Coloproctology, 38*, 207–213. doi:10.1016/j.jcol.2018.03.005

Peterson, Z. D., Janssen, E., & Laan, E. (2010). Women's sexual responses to heterosexual and lesbian erotica: The role of stimulus intensity, affective reaction, and sexual history. *Archives of Sexual Behavior, 39*, 880–897. doi:10.1007/s10508-009-9546-y

Prause, N., Roberts, V., Legarretta, M., & Cox, L. M. R. (2012). Clinical and research concerns with vibratory stimulation: A review and pilot study of common stimulation devices. *Sexual and Relationship Therapy, 27*, 17–34. doi:10.1080/14681994.2012.660141

Pulverman, C. S., Hixon, J. G., & Meston, C. M. (2015). Uncovering category specificity of genital sexual arousal in women: The critical role of analytic technique. *Psychophysiology, 10*, 1396–1408. doi:10.1111/psyp.12467

Rieger, G., Chivers, M. L., & Bailey, J. M. (2005). Sexual arousal patterns of bisexual men. *Psychological Science, 16*, 579–584. doi:10.1111/j.1467-9280.2005.01578.x

Rieger, G., Cash, B. M., Merrill, S. M., Jones-Rounds, J., Dharmavaram, S. M., & Savin-Williams, R. C. (2015). Sexual arousal: The correspondence of eyes and genitals. *Biological Psychology, 104*, 56–64. doi:10.1016/j.biopsycho.2014.11.009

Rights, J. D., & Sterba, S. K. (2019). Quantifying explained variance in multilevel models: An integrative framework for defining R-squared measures. *Psychological Methods, 24*,

309–338. doi:10.1037/met0000184

Sakaki, M., Niki, K., & Mather, M. (2011). Beyond arousal and valence: The importance of the biological versus social relevance of emotional stimuli. *Cognitive, Affective, & Behavioral Neuroscience, 12*, 115–139. doi:10.3758/s13415-011-0062-x

Sarin, S., Amsel, R., & Binik, Y. M. (2016). A streetcar named "derousal"? A psychophysiological examination of the desire-arousal distinction in sexually functional and dysfunctional women. *Journal of Sex Research, 53*, 711–729. doi:10.1080/00224499.2015.1052360

Shifren, J. L., Monz, B. U., Russo, P. A., Segreti, A., & Johannes, C. B. (2008). Sexual problems and distress in United States women: Prevalence and correlates. *Obstetrics & Gynecology, 112*, 970–978. doi:10.1097/AOG.0b013e3181898cdb

Spape, J., Timmers, A. D., Yoon, S., Ponseti, J., & Chivers, M. L. (2014). Gender-specific genital and subjective sexual arousal to prepotent sexual features in heterosexual women and men. *Biological Psychology, 102*, 1–9. doi:10.1016/j.biopsycho.2014.07.008

Styles, S. J., MacLean, A. B., Reid, W. M. N., & Sultana, S. R. (2006). Laser Doppler perfusion imaging: A method for measuring female sexual response. *BJOG: An International Journal of Obstetrics & Gynaecology, 113*, 599–601. doi:10.1111/j.1471-0528.2006.00894.x

Suh, D. D., Yang, C. C., Cao, Y., Heiman, J. R., Garland, P. A., & Maravilla, K. R. (2004). MRI of female genital and pelvic organs during sexual arousal. *Journal of Psychosomatic Obstetrics & Gynecology*, *25*, 153–162. doi:10.1080/01674820400002220

Suschinsky, K. D. (2012). *An exploration of genital arousal category-specificity and sexual concordance in men and women* (Doctoral dissertation). University of Lethbridge, Lethbridge, AB, Canada.

Suschinsky, K. D., Dawson, S. J., & Chivers, M. L. (2020). Assessing gender-specificity of clitoral responses. *The Canadian Journal of Human Sexuality*. Advanced online publication. doi:10.3138/cjhs.2019-0061

Suschinsky, K. D., & Lalumière, M. L. (2011a). Prepared for anything? An investigation of female genital arousal in response to rape cues. *Psychological Science*, *22*, 159–165. doi:10.1177/0956797610394660

Suschinsky, K. D., & Lalumière, M. L. (2011b). Category-specificity and sexual concordance: The stability of sex differences in sexual arousal patterns. *The Canadian Journal of Human Sexuality, 20*, 93–108.

Suschinsky, K. D., Lalumière, M. L., & Chivers, M. L. (2009). Sex differences in patterns of genital sexual arousal: Measurement artifacts or true phenomena? *Archives of Sexual Behavior*, *38*, 559–573. doi:10.1007/s10508-008-9339-8

Tavares, I. M., Vardasca, R., Cera, N., Pereira, R., Nimbi, F. M., Lisy, D., . . . Nobre, P. J. (2018). A review of infrared thermography as applied to human sexual psychophysiology. *International Journal of Psychophysiology, 133*, 28–40. doi:10.1016/j.ijpsycho.2018.09.001

Thorson, K. R., Mendes, W. B., & West, T. V. (2019). Controlling the uncontrolled: Are there incidental experimenter effects on physiologic responding? *Psychophysiology, 57*, e13500. doi:10.1111/psyp.13500

Timmers, A. (2019). *Attractiveness and sexual response* (Doctoral dissertation). Queen's University, Kingston, ON, Canada.

Timmers, A. D., Bouchard, K. N., & Chivers, M. L. (2015). Effects of gender and sexual activity cues on the sexual responses of women with multidimensionally defined bisexuality. *Journal of Bisexuality, 15*, 154–179. doi:10.1080/15299716.2015.1023389

Timmers, A. D., & Chivers, M. L. (2012). Sociosexuality and sexual arousal. *The Canadian Journal of Human Sexuality, 21*, 135–147.

Traish, A. M., Botchevar, E., & Kim, N. N. (2010). Biochemical factors modulating female genital sexual arousal physiology. *The Journal of Sexual Medicine, 7*, 2925–2946. doi:10.1111/j.1743-6109.2010.01903.x

Trivers, R. L. (1972). Parental investment and sexual selection. In B. Campbell (Ed.), *Sexual selection and the descent of man 1871–1971* (pp. 136–207). Chicago, IL: Aldine Publishing Company.

Waxman, S. E., & Pukall, C. F. (2009). Laser Doppler imaging of genital blood flow: A direct measure of female sexual arousal. *The Journal of Sexual Medicine, 6*, 2278–2285. doi:10.1111/j.1743-6109.2009.01326.x

Woodard, T. L., & Diamond, M. P. (2009). Physiologic measures of sexual function in women: A review. *Fertility and Sterility, 92*, 19–34. doi:10.1016/j.fertnstert.2008.04.041

Table 6.1

Proportion of Women From Chapter Two Who Demonstrated Cue-Specificity, Defined According to Three Different Parameters, for Genital Lubrication and for Vaginal Vasocongestion

	Any difference % (*n*)	>0.5 *SD* % (*n*)	>1.0 *SD* % (*n*)
Genital Lubrication	68% (13)	63% (12)	47% (9)
Vaginal Vasocongestion	58% (11)	42% (8)	21% (4)

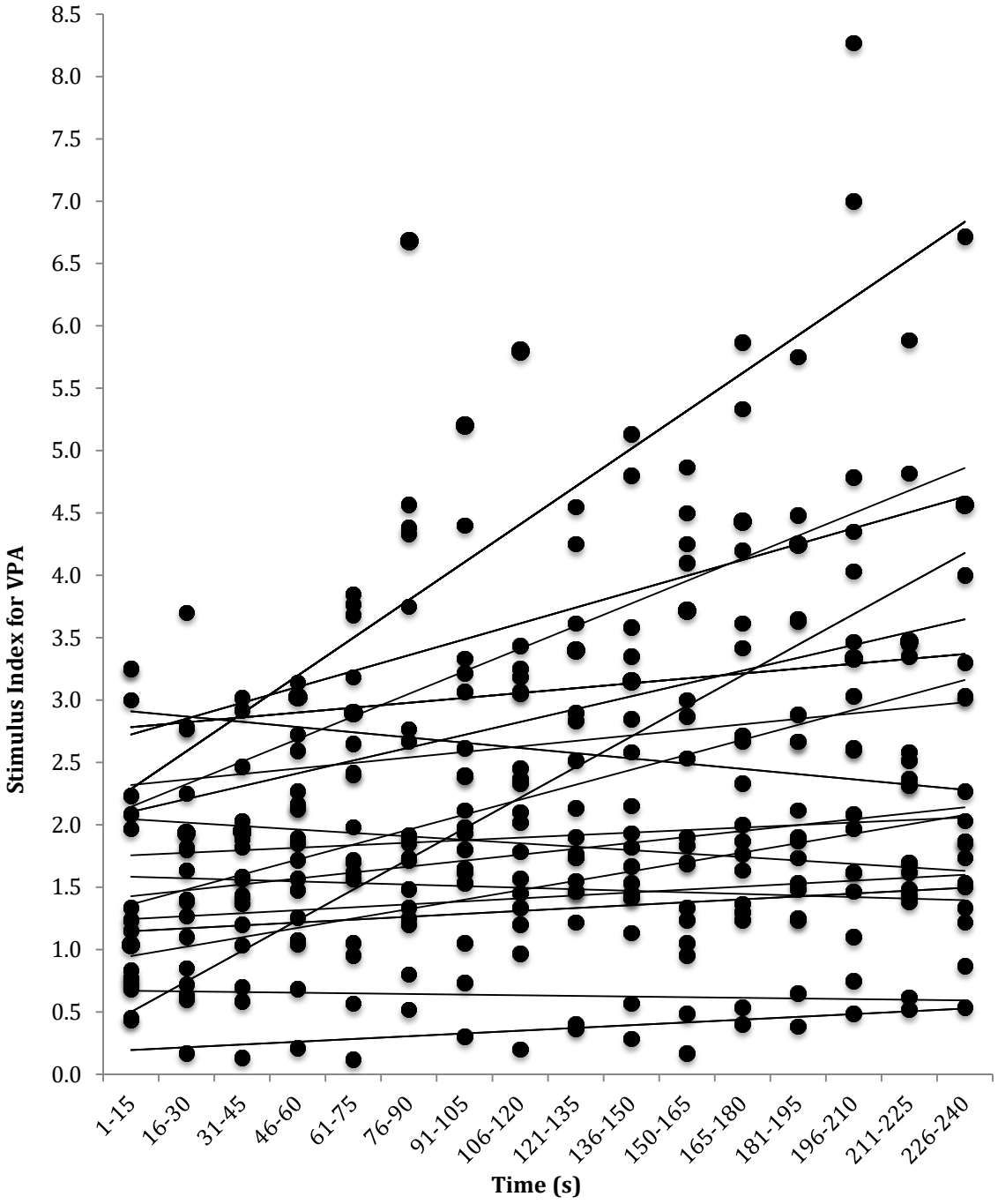

Figure 6.1. Stimulus index values for vaginal pulse amplitude (VPA) assessed with VPP, and associated linear trend lines across all time epochs for each female participant in Chapter Three.