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## Sex in the Brain: The Relationship between Event Related Potentials and Subjective Sexual Arousal

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SEX IN THE BRAIN: THE RELATIONSHIP BETWEEN EVENT RELATED  
POTENTIALS AND SUBJECTIVE SEXUAL AROUSAL

by

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Bachelor of Arts in Psychology  
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A dissertation submitted in partial fulfillment  
of the requirements for the

Doctor of Philosophy- Psychology

Department of Psychology  
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**May 2014**

## ABSTRACT

### **Sex in the Brain: The Relationship between Event Related Potentials and Subjective Sexual Arousal**

by

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Research investigating the relationship between subjective sexual arousal and physiological arousal has focused primarily on measures of genital arousal and has yielded only modest concordance rates between genital and subjective sexual arousal in men, and low concordance rates in women. One of the nagging confounds in the literature, however, has been the fact that different assessment methods are necessitated by men and women's differing genital physiology (i.e., vaginal photoplethysmography in women and penile plethysmography in men). This study sought to investigate the relationship between subjective sexual arousal and a different type of physical arousal (brain activation) that could be measured in the same fashion for men and women (EEG) and that arguably should have a closer relationship to the mental and emotional experience of sexual arousal. Subjective sexual arousal and ERPs to auditory tones (specifically, auditory N1 and P3 amplitudes) were collected from 19 heterosexual women and 19 heterosexual men while they viewed a film of a man and a woman cooking a meal, and an erotic film of a man and a woman engaging in oral and penetrative sex. There were three main hypotheses: that men would report significantly

more subjective sexual arousal to the erotic film than women; that men would evidence significantly smaller N1s and P3s when viewing the erotic film than women; and that participants' subjective sexual arousal would significantly correlate positively with N1 amplitudes and negatively with P3 amplitudes in the erotic film condition. We did not expect a gender difference in these correlations. Contrary to the first hypothesis, women reported more sexual arousal to the erotic film than did men. In terms of the second hypothesis, we failed to find a gender by film-type interaction on N1, but we did find a significant gender by film-type by order interaction on P3 ERP amplitudes. Simple effects revealed that men evidenced significantly smaller P3 amplitude to the cooking film than did women. Lastly, there was partial support for the third hypothesis: We found a significant positive correlation between N1 amplitude and subjective sexual arousal in men, as well as a significant negative correlation between the P3 amplitude and subjective sexual arousal in women. Results are interpreted to possibly indicate that sexual arousal may interfere with early processing of tones for men, while it may interfere with later processing of tones for women. Furthermore, concordance rates between ERP/subjective sexual arousal were stronger than the average concordance rates between genital plethysmography/subjective sexual arousal for both men and women. More research should be conducted to investigate whether ERPs are more closely aligned with reports of subjective sexual arousal in men and women and to test the replicability of gender differences in concordances between N1 amplitudes and subjective sexual arousal and P3 amplitudes and subjective sexual arousal found in this study.

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## DEDICATION

To mom and dad: You are such amazing role models and impactful leaders in your community. You have been an inspiration to many, including Sarah and me. I have always felt supported and loved, and that makes everything else in life seem a bit more manageable. I love you both, and I am honored to call you my parents.

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## CHAPTER 1

### INTRODUCTION

The primacy of sexual desire and arousal is at the heart of much theorizing about human motivation. From classical psychoanalytic theory to socio-evolutionary explanations for behavior, sexual desire and arousal feature prominently as key organizers of individual and social actions. However, much about these complex phenomena has yet to be adequately understood - an understanding that potentially has important clinical and experimental implications. For example, gaining insight about these sexual experiences could be instrumental in the treatment of the many individuals who report difficulties with sexual desire and arousal, with concomitant deficits in their individual and relational well-being. In the largest community epidemiological study in the United States, deficits in sexual desire were reported by over 33% of women and 16% of men. Erectile difficulties were reported by 10% of men, premature ejaculation by 28%; 19% of women reported problems with lubrication (Laumann, Gagnon, Michael, & Michaels, 1994). Efficacious clinical interventions, however, require that we understand the constructs of desire and arousal and their complex relationship to each other and to the contexts in which they are facilitated or interfered with.

One of the intriguing findings in the literature relates to the relationship between physical and subjective indicators of sexual arousal. Typically, psychologists have used objective measures of genital arousal in both men and women to assess physical arousal, and self-report measures to assess subjective arousal. However, low concordance rates between these two agreed-upon dimensions of arousal continue to confound researchers, especially in regard to women. One would expect physiological arousal to be

accompanied by subjective arousal and vice versa. Yet this pairing has been much more tenuous than expected, at least when physiological arousal has been assessed via genital blood flow (vasocongestion). In fact, a recent meta-analysis on concordance rates between genital and subjective sexual arousal revealed that women evidence a surprisingly low agreement between these two measures ( $r = .26$ ; Chivers, Seto, Lalumière, Laan, & Grimbos, 2010).

The nature of this discordance has been of great interest to investigators. Low concordance rates between genital and subjective sexual arousal in women could result from consistently low genital arousal or consistently moderate-high genital arousal accompanied by widely varying levels of subjective arousal. Low concordance rates could also emanate from consistently low or high subjective arousal accompanied by widely varying genital arousal. Research, however, indicates that the discordance is attributable primarily to the fact that women experience vasocongestion relatively indiscriminately when presented with intense sexual stimuli, regardless of their subjective arousal ratings. In fact, genital arousal in women seems to be almost entirely contingent on the explicitness of the sexual stimuli. The gender of the actor in the sex scenes has little effect on genital arousal with heterosexual women evidencing as much genital arousal to sexual scenes involving women as those involving men (Chivers, Seto, & Blanchard, 2007). Women have even been shown to arouse genitally when exposed to video clips of bonobos copulating, despite the fact that they claim to experience no subjective sexual arousal when viewing these images (Chivers & Bailey, 2005). In light of these results, some have proposed that women's category non-specific genital arousal constitutes an evolutionary adaptation to facilitate penile penetration and avoid injury,

lest unwanted or coercive sex is unavoidable (Chivers et al., 2007). Regardless of the explanations for this automatic and category non-specific genital arousal response, it seems that genital arousal is not very predictive of subjective sexual arousal in women.

Given that genital arousal is not a strong predictor of subjective arousal in women, the question remains; is there any other objective measure that would correlate higher (than genital arousal) with subjective arousal in women? Perhaps, if one were to turn to an objective measure that would intuitively be more closely aligned with subjective feelings of sexual interest, the correlation would be higher. One such objective measure would be visual attention. Generally speaking, visual attention is captured by images that hold some interest, either for reasons of attraction, or disgust, or fear, or informative value. Certainly, visual attention can be theorized to be the first step in the information processing of sexually appealing stimuli.

In fact, when participants have been asked to view photographs of partially clothed women, partially clothed men, and landscapes, eye gaze was positively correlated with sexual appeal ratings (Strassberg, 2009). However, when the visual attention patterns of men and women viewing erotic stimuli are compared, the same category non-specific pattern emerges for women. While heterosexual men focus almost exclusively on the woman in images of nude couples engaged in sexual foreplay, women show a much more diffuse visual attention pattern, focusing almost equally on the male as on the female images (e.g., Lykins, Meana, & Strauss, 2008). Much as in the case of genital arousal, women's stated erotic preferences are not very predictive of where and for how long her gaze will fixate. Potential explanations for this category non-specific viewing pattern are perhaps more complex than potential explanations for category non-specific

genital arousal. After all, visual attention should be more closely linked to subjective arousal than lubrication. It seems fairly intuitive to state that we look at what we find attractive. However, it is possible that heterosexual women gaze at other women for non arousal-based reasons, such as social comparison reasons or perhaps because of a greater empathic orientation toward all human images in a photograph or video. Research has yet to determine empirically what lies behind this diffuse and category non-specific visual attention pattern in women.

If subjective sexual arousal in women has little relation to genital changes or to eye movements, where in the body can we find it? Is there any physiological referent for the mental and emotional experience of feeling "turned on" for women? The brain seems the obvious next place to investigate. If subjective sexual arousal is a mental and emotional event, one would expect that an objective measure of brain activity should capture it. In fact, one study has found a relationship between the auditory P3 component of the ERP and subjective sexual arousal scores when participants were asked to watch a sexually explicit video while being presented with an auditory odd-ball paradigm (Vardi et al., 2006). Although this initial study shows promise, more research is needed to fully understand the relationship between subjective sexual arousal and brain activation. Most importantly, if brain activation is a stronger predictor of subjective sexual arousal than are genital arousal or visual attention, it also stands to reason that women's brain activation should appear more category-specific, much like their subjective sexual arousal. No prior research has investigated this hypothesis.

In an attempt to elucidate the correlates of subjective sexual arousal in women, this dissertation will first review the literatures on concordance rates between genital and

subjective sexual arousal, category specificity of genital arousal, category specificity of visual attention, and concordance of brain activation and subjective sexual arousal. This literature review will be followed by a description of the proposed experimental study to investigate the concordance of subjective sexual arousal and brain activation, as well as the category specificity of said activation. The meta aim of this work is to gain a greater understanding of female sexual desire and subjective arousal. Women's stated erotic preferences and phenomenological experience of sexual excitement remain un-anchored by any reliable physical or objective referent. This study attempts to test the one physical referent that would be most likely to correspond to the phenomenology of eroticism – the brain.



## CHAPTER 2

### LITERATURE REVIEW

#### **Genital Vasocongestion and Subjective Sexual Arousal**

Most prior research has relied upon genital vasocongestion to measure physical sexual arousal (specifically through vaginal photoplethysmography in women and penile plethysmography in men), and Likert-type scales to measure subjective sexual arousal. Concordance rates have varied greatly from study to study, even when assessment tools across studies have been the same. When comparing concordance rates by sex, large differences have been found, with men typically evidencing higher concordance rates than women. We will organize our review of these studies by size of the concordance rate (low as  $r < .30$ , medium as  $r$  between .29 and .61, and high as  $r > .60$ ). As research papers sometimes report multiple concordance rates (referring to multiple groups within a study), we will consider each concordance rate separately in this paper.

Table 1

*Number of Reports of Low, Moderate, or High Concordance Rates of Genital Vasocongestion and Subjective Sexual Arousal in the Literature\*, by Sex.*

	$r < .30$	$.29 < r < .61$	$r > .60$
Men	17	42	50
Women	76	58	27
Total	93	100	77

\* The literature consisted of 43 research papers conducting studies exclusively on women, 31 research papers conducting studies exclusively on men, and 15 research papers conducting studies on both sexes.

**Low concordance rates.** As illustrated in Table 1, there are a substantial number of reports of low concordance rates between subjective sexual arousal and genital vascongestion. In regards to sex, a striking 76 out of 93 studies yielded low concordance rates in women; only 17 such studies found low correlations in men. Some studies did not report an  $r$  when the correlation between genital vasocongestion and subjective sexual arousal was not statistically significant, thus we included them in our tally of low correlations in Table 1 (Cerny, 1978; Laan, Everaerd, Van Anhold, & Rebel, 1993; McConaghy, 1969; Messè & Geer, 1985; Morokoff, 1985; Osborn & Pollack, 1977; Stock, 1983). Excluding these studies that failed to report concordance rates when no significance was found, 56% of the 73 remaining studies that reported low concordance rates reported correlations of less than .15 (Bach, Brown, & Barlow, 1999; Both et al., 2004; Both, Everaerd, Laan, & Gooren, 2005; Both, Van Boxtel, Stekelenburg, Everaerd, & Laan, 2005; Brotto & Gorzalka, 2002; Chivers, 2003; Dekker & Everaerd, 1988; Elliott & O'Donohue, 1997; Gaither, Rosenkranz, Amato-Henderson, Plaud, & Bigwood, 1996; Graham et al., 2000; Heiman, Rowland, Hatch, & Gladue, 1991; Hoon, 1980; Laan, Everaerd, van Bellen, & Hanewald, 1994; Laan, Everaerd, van Berlo, & Rijis, 1995; Meston, 2004; Osborn & Pollack, 1977; Peterson & Janssen, 2007; Rellini, McCall, Randall, & Meston, 2005; Rubinsky, Eckerman, Rubinsky, & Hoover, 1985; Schacht et al., 2007; Schreiner-Engel, Schiavi, & Smith, 1981; Wilson & Lawson, 1978). Of these, a vast majority was conducted on women (31 out of the 41 studies). Thirty-four percent of all studies that reported low concordance rates had a correlation between  $r = .15$  and  $r = .30$ , with a majority (75%) of these studies conducted on women, showing a disproportionate number of studies showing low concordance rates being conducted on

women (Cerny, 1978; Dekker & Everaerd, 1988; Elliott & O'Donohue, 1997; Geer, Morokoff, & Greenwood, 1974; Hoon, 1980; Laan, Everaerd, Van Aanhoud, & Rebel, 1993; Laan et al., 1994; Laan et al., 1995; Lake Polan et al., 2003; Wincze, Venditti, Barlow, & Mavissakalian, 1980).

**Moderate concordance rates.** Many studies on both men and women have shown moderate concordance rates for subjective sexual arousal and physical sexual arousal via genital plethysmography. Although the number of reports of moderate concordance rates is comparable between sexes ( $N = 42$  for males and  $N = 58$  for females), sex differences continue to emerge upon further consideration. Women were the focus of 75% of studies with reported correlations between  $r = .29$  and  $r = .45$  (Both, Everaerd, et al., 2005; Both, Van Boxtel, et al., 2005; Brotto & Gorzalka, 2002; Chivers, 2003; Dekker & Everaerd, 1988; Heiman & Hatch, 1980; Hensen & Rubin, 1978; Laan et al., 1993; Laan et al., 1995; Laan & Everaerd, 1995; Morokoff, 1985; Schreiner-Engle, Schiavi, & Smith, 1981; Stock, 1983; Wincze, Hoon, & Hoon, 1977). The remaining 25% of studies with concordance rates between  $r = .29$  and  $r = .45$  were conducted on men (Briddell, Rimm, Caddy, Krawitz, Sholis, & Wunderlin, 1978; Chivers, 2003; Dekker & Everaerd, 1988; Farkas, Sine, & Evans, 1979; Malamuth & Check, 1980; Rubinsky et al., 1985; Sakheim, Barlow, Beck, & Abrahamson, 1985; Tollison, Adams, & Tollison, 1979). In contrast, 53% of studies reporting concordance rates between  $r = .44$  and  $r = .61$  were conducted on men (Adams, Wright, & Lohr, 1996; Apperloo et al., 2006; Both et al., 2004; Briddell et al., 1978; Chivers, 2003; Farkas et al., 1979; George et al., 2006; Heiman, 1977; Julien & Over, 1988; Malamuth & Check, 1980; Mavissakalian, Blanchard, Abel, & Barlow, 1975; O'Donohue & Geer, 1985; Peterson &

Janssen, 2007; Sakheim et al., 1985; Tollison et al., 1979; Weisberg, Brown, Wincze, & Barlow, 2001; Wormith, 1986), while 47% were conducted on women (Chivers, 2003; Chivers et al., 2007; Exton et al., 1999; Heiman, 1977; Heiman et al., 2001; Korff & Geer, 1983; Laan et al., 1995; Meuwissen & Over, 1990; Rubinsky et al., 1985; Schreiner-Engle et al., 1981; Seal, Brotto, & Gorzalka, 2005; Steinman, Wincze, Sakheim, Barlow, & Mavissakalian, 1981; ter Kuile, Vigeveno, & Laan, 2007). Therefore, it seems that in regards to moderate concordance rates in subjective and physical sexual arousal measured via genital plethysmography, there are no large differences between men and women.

**High concordance rates.** The tally of reports of high concordance rates between subjective sexual arousal and physical sexual arousal via genital plethysmography shows clear and large sex differences, much as the tally for reports of low concordance rates. High concordance rates are documented almost twice as much in studies involving men than in those involving women. To break it down further, 57% of studies reporting concordance rates between  $r = .59$  and  $r = .75$  were conducted on men (Abel, Blanchard, Murphy, Becker, & Djenderedijian, 1981; Adams et al., 1996; Bancroft, 1971; Barlow, Sakheim, & Beck, 1983; Both, Everaerd, et al., 2005; Chivers, 2003; Hall, Binik, & DiTomasso, 1985; Heiman & Hatch, 1980; Julien & Over, 1988; Sakheim et al., 1985; Tolison et al., 1979; Wincze et al., 1980; Wincze & Qualls, 1984); with 43% of studies with such concordance rates focusing on women (Cerny, 1978; Heiman et al., 2001; Korff & Geer, 1983; Meuwissen & Over, 1990; Meuwissen & Over, 1992). Studies with very high concordance rates (that is, correlations of  $r = .75$  and above) show a large sex difference. Particularly, 73% of all studies that found very high concordance rates were

conducted on men (Chivers et al., 2007; Gaither, 2001; Gaither & Plaud, 1997; Heiman & Hatch, 1980; Julien & Over, 1988; Koukounas & McCabe, 2001; Koukounas & Over, 1999; Lohr, Adams, & Davis, 1997; Mitchell, DiBartolo, Brown, & Barlow, 1998; Sakheim et al., 1985; Smith & Over, 1987; Steinman et al., 1981; Wilson, Niaura, & Adler, 1985; Wincze & Qualls, 1984); leaving only 27% of such studies reporting concordance rates of  $r = .75$  and above in women (Korff & Geer, 1983; Seal et al., 2005). Therefore, it seems that high correlations between subjective sexual arousal and physical sexual arousal (via genital plethysmography) are much higher in men than in women.

**A representative physical/subjective arousal concordance study.** Given the large number of studies that have investigated the concordance between genital arousal measured via plethysmography and subjective arousal, it is not feasible for this literature review to describe them all in detail. However, to illustrate the sex differences that emerge when investigating concordance rates of subjective and physical sexual arousal via genital photoplethysmography, we have chosen a recent study that resembles many prior ones so as to give the reader a sense of representative methodology and results.

Peterson and Janssen (2007) investigated the effect of mood (specifically ambivalence) on sexual arousal in both men and women. In this study, 26 healthy women and 19 healthy men (mean age 20.3 years old) were exposed to four sexual film excerpts lasting three minutes each. Two erotic film clips were selected from a prior study (Janssen, Carpenter, & Graham, 2003) because the first was the most sexually arousing for female viewers (i.e., the “female-selected film”); while the second was the most sexually arousing for male viewers (i.e., the “male-selected film”). The third excerpt was a segment from the movie *A Reason to Believe*, in which a coercive sexual

encounter was depicted (i.e., “coercive film”). For the fourth and last film excerpt, men viewed the second highest-ranking male-favored video and women viewed the second highest-ranking female-favored video from the Janssen et al. (2003) study. In sum, men and women both viewed three identical film clips (the highest male-ranked clip, the highest female-ranked clip, and the coercive sex clip); then men viewed the male-favored runner up clip and women viewed the female-favored runner-up clip. Vaginal photoplethysmography and penile plethysmography were used to measure physical arousal, and a questionnaire using a Likert-type scale (ranging from 1 = “not at all” to 7 = “very strong”) was used to assess a variety of subjective reactions to the video (including interest, sensual arousal, and feelings of passion).

In all four film conditions, men evidenced higher correlations between subjective and physical sexual arousal than women. Specifically, concordance rates were higher for men in the “female-centered” film ( $r = .46$  vs.  $r = .06$ ), the “male-centered” film ( $r = .52$  vs.  $r = .20$ ), the “coercive” film ( $r = .26$  vs.  $r = .12$ ), and the “runner-up” film ( $r = .51$  vs.  $r = .01$ ). Interestingly, the film clips categorized as most sexually arousing to women (i.e., “female-centered” films) had the lowest concordance rates between subjective and physical arousal in women. In any case, this study demonstrated that levels of subjective sexual arousal did not seem to predict physical sexual arousal via vaginal plethysmography in women. This clearly shows that sex differences emerge when measuring concordance rates between subjective and physical sexual arousal (via genital photoplethysmography), even when the sexual stimuli is the same for both sexes.

### **Category Specificity of Genital Arousal**

There are three possible configurations for women's low concordance rates between subjective sexual arousal and genital plethysmography. The first would be that both genital and subjective arousal vary widely but with little relation to each other; the second would be that subjective reports of sexual arousal are stable across stimuli while genital vasocongestion is variable; alternately, women may evidence genital arousal to all manner of sexual stimuli regardless of their reports of subjective arousal.

While both men and women typically report substantially category specific subjective sexual arousal (i.e., subjectively reporting more sexual arousal to stated erotic preferences), genital vasocongestion appears to function differently in men and women. In an elegant series of studies, Chivers and colleagues found that on average, men evidence category-specific genital arousal (ergo the moderate to high concordance rates between vasocongestion and subjective reports of arousal), while women seem to arouse genitally more as a function of the sexual explicitness/intensity of the stimulus rather than the gender (or even species) of the actor(s)(ergo the lower concordance rates in women). In other words, given a certain sexual explicitness, women will genitally arouse relatively indiscriminately, while their subjective arousal will vary as a function of their stated erotic preferences.

In the first of her series of studies, Chivers and colleagues investigated sex differences in category specificity by asking heterosexual natal men, heterosexual natal women, and male-to-female (MtF) transsexuals to view films of heterosexual couples, same-sex male couples, and same-sex female couples engaging in penetrative and oral sex. While viewing the films, participants were instructed to report their continuous subjective sexual arousal by moving a lever that rotated 180 degrees. Physical sexual

arousal was measured via genital plethysmography. In order to focus on the differences in sexual arousal between men and women, the findings on MfF transsexuals will be not be discussed here but rather at a later time. For women, subjective sexual arousal was relatively category-specific. However, in regards to genital vasocongestion, women evidenced no significant difference in genital arousal to the male-male couple and male-female couple erotic films. For men, there was a clear preference for scenes where women were present, both in subjective reports and genital arousal. Thus, women's genital arousal appeared to be relatively unrelated to their erotic preferences while men's genital arousal aligned much more closely to their subjective arousal.

To further investigate the extent to which women's genital arousal was non-category specific, Chivers & Bailey (2005) introduced into their experimental paradigm scenes of non-human primates copulating. In addition to the films on heterosexual, gay, and lesbian couples engaging in sex acts described above, the authors asked 18 heterosexual women and 18 heterosexual men to view a two-minute film of two bonobos (a male and female) engaging in penetrative sex. Again, subjective sexual arousal was measured via a lever; physical sexual arousal was measured via genital plethysmography. As found previously, both men and women reported more subjective sexual arousal to their stated erotic target but women exhibited genital arousal to all manner of sexual stimuli, this time including a bonobo mating video (Chivers & Bailey, 2005). Thus, it seems that even non-human sexual encounters can elicit a genital response in women.

In the last of her series of studies, Chivers and colleagues (2007) tried to tease apart the extent to which the gender of the actor or the intensity of the sexual activity depicted differentially impacted the genital arousal of men and women. Participants



viewed films of two men engaging in sexual intercourse, two women engaging in sexual activities, a man engaging in masturbation, a woman engaging in masturbation, a man exercising nude, a woman exercising nude, and lastly bonobos copulating. Genital arousal in men was highly contingent on the gender of the actors in the video. For example, a woman exercising produced genital arousal for heterosexual men, although not as much as a woman in a sexual scenario. Men in any filmed scenario did not trigger significant sexual arousal (either subjectively or genitally) in heterosexual men. For women, however, it was the intensity of sexual activity depicted that best predicted their genital arousal, regardless of the gender of the actors. Any intensely sexual scene, whether the actors were men or women, triggered genital arousal in women. Even images of their erotic targets exercising produced no results. Thus, the presence of any sexual stimulus appears to trigger a genital response in women, a response unrelated to their subjective desires. However, both men and women's subjective reports were higher for their preferred erotic target than their non-preferred erotic target. This is at the heart of why concordance rates are so low in women in comparison to men.

### **Explaining Sex Differences in Concordance Rates**

The sex difference in concordance rates between subjective sexual arousal and genital vascongestion have long been considered an intriguing finding for which researchers and theoreticians have sought an explanation. Some have tried to explain the difference away as a function of methodological confounds. Others have argued that the difference is real and consistent with specific theories of human behavior, physiology, and evolution. This section will review these explanations.

### **Methodological artifact: Comparison across different measures of arousal.**

Because men and women have different genital anatomy, the measurement of genital arousal has, for the most part, been conducted with different instruments that yield different types of outcomes. Penile plethysmography infers vasocongestion from changes in penile circumference or volume. Vaginal photoplethysmography infers vasocongestion from changes in light reflected back from vaginal walls into the photoplethysmograph or in changes in pulse recorded within the vagina. Therefore, although these two measurements purport to be measuring the same process, they necessarily measure slightly different properties of physical sexual arousal in men and women (Chivers et al., 2010). In fact, Kukkonen et al. (2007) has claimed that when the same measure of physical sexual arousal is used in both sexes (such as genital thermography), women's concordance rates become higher, and the concordance rates between men and women are no longer significantly different.

In addition, the validity and reliability of each measure may differ. For example, penile plethysmography has shown to discriminate reliably between sexually functional and dysfunctional men, but vaginal photoplethysmography has been a much less reliable discriminator between sexually functional and dysfunctional women (Chivers et al., 2010). One possibility is that vaginal photoplethysmography, which is a much more indirect measurement of blood flow than penile volume increases, might not be as able as the penile plethysmograph to detect small changes in arousal. Therefore, some critics have suggested that the difference in physical sexual arousal may be a mere methodological artifact and that if men and women were measured in the same way, these differences might disappear. For this reason, some have argued that a comparison

between men and women on sexual arousal via genital plethysmography cannot, or should not, be made (Steinman et al., 1981).

Chivers, Rieger, Latty and Bailey (2004) tried to address this issue directly in one of their studies on category specificity of sexual arousal in heterosexual and homosexual men and women, and heterosexual and homosexual male-to-female (MtF) transsexuals. By assessing genital arousal in MtF transsexuals who had neo-vaginas, the authors could, in effect, use a vaginal plethysmograph with a natal male and thus address the methodological artifact question directly. As described previously, participants were asked to view videos of heterosexual couples, same-sex males, and same-sex females engaging in penetrative and oral sex while reporting their subjective sexual arousal via a lever. In regards to subjective sexual arousal, the MtF transsexuals evidenced a relatively category-specific arousal. However, much like the men, all MtF transsexuals evidenced more genital arousal for their preferred sex stimuli than for their non-preferred sex stimuli. That is, they evidenced a male pattern of genital arousal category-specificity although the vasocongestion in these natal men was measured via vaginal photoplethysmograph. It would clearly be preferable to be measuring arousal with the same instrument in men and women, but the data on vaginal photoplethysmography with biological males (male-to-female transsexuals with surgically constructed vaginas) goes some way toward dispelling the notion that measurement issues completely explain away the sex differences.

**Methodological artifact: Analyzing/convertting data into concordance rates.**

Another possible methodological issue which could constitute a confound across studies is the way in which researchers analyze and/or convert the data in order to obtain

concordance rates. Some have hypothesized that the way in which concordance rates are obtained and/or how data is collected and analyzed may differentially affect men and women's concordance rates of subjective/objective sexual arousal.

In terms of data collection, reduction of genital plethysmography data is necessary as it is possible to get up to 100 recordings of physical sexual arousal per second. Many researchers thus opt to average a section of time (e.g., 5 seconds, 15 seconds, or 30 seconds) and then use those reduced numbers in a correlation with subjective sexual arousal scores in order to achieve concordance rates (Wiederman & Whitley, 2002). Furthermore, data transformation can also be involved when operationalizing physical sexual responses. Often, researchers will subtract the participant's baseline genital vasocongestion from his/her genital response during sexual arousal (Wiederman & Whitley, 2002). For example, if a man's baseline penile circumference is 100 mm and his maximum circumference is 150 mm when he is viewing a sexual film, his genital response to the stimuli would be 50 mm. Beyond the obvious sex differences in measurement (penile plethysmography measures in millimeters, while vaginal photoplethysmography measures in megavolts), another issue arises with baseline measures for women when using vaginal photoplethysmography. Blood flow and/or temperature in the vagina often does not return to pre-sex stimulus "baseline" measures immediately after viewing sexually arousing stimuli. Yet some researchers use a "post sexual stimuli" baseline measure of genital arousal while others use the "pre sexual stimuli" baseline measure (Wiederman & Whitley, 2002). This, of course, could greatly affect physical sexual arousal data, and may affect concordance rates with subjective sexual arousal uniquely in women.

Variation in the measurement of subjective sexual arousal might also be problematic when comparing genders. In their meta-analysis, Chivers and colleagues' found significant gender differences when subjective sexual arousal was assessed at the end of each stimulus, but not when a contiguous method of subjective sexual arousal was implemented instead. Specifically, men's concordance rates decreased when contiguous methods were used; women's subjective sexual arousal did not seem to be affected by the type of the subjective sexual assessment (Chivers et al; 2010). Therefore, although constant assessment of sexual arousal may prove to be a cognitive distraction for men that negatively affects their physical sexual arousal, differences in the assessment of subjective sexual arousal do not seem to explain why women's concordance rates remain so low.

Lastly, it is possible that within-subject, between-subject, or mixed design correlations may differentially affect men and women's concordance rates between subjective and physical sexual arousal. For both men and women, Chivers et al. (2010) found that within-subject correlations of subjective/objective sexual arousal were significantly larger than between-subject correlations. However, regardless of the type of correlation used, men still evidenced significantly higher concordance rates than women. Therefore, based on the evidence provided, it seems that statistical methods cannot fully explain the gender differences in concordance rates.

**Methodological artifact: Social desirability.** Some researchers have posited that the sex difference in concordance rates may be attributable to women answering in a more socially desirable way (reporting less subjective arousal than they actually feel). Given that social convention favors more modest sexual expression in women (Nicolson

& Burr, 2003), they may be underestimating and/or under-reporting their subjective arousal to either feel or appear less "sexual." In contrast, social convention is much more encouraging of sexual expression in men and, thus, they may be over-estimating and/or over-reporting their subjective sexual arousal (Alexander & Fisher, 2003).

Prior research has shown sex differences in reported sexual behaviors; men report up to four times as many opposite-sex sexual partners than women (Brown & Sinclair, 1999). This statistic is impossible, as a random sample of heterosexual men should have approximately equivalent partners as a random sample of heterosexual women in terms of averages; a new partner for a heterosexual man implies a new partner for a heterosexual woman. Of course, this does not mean that any one man could not have more partners than any one woman. A number of reasons have been posited for the reporting differences, including under-sampling of sex workers as well as sex-differentiated definitions of what constitutes a sexual partner or a sexual encounter (Brown & Sinclair, 1999). However, the most likely explanation for the discrepancy in reported sexual partners is social desirability. Men are likely over-reporting and women are likely under-reporting for reasons of esteem-enhancement and impression management. If social desirability is at play in the reporting of number of sex partners, there is good reason to hypothesize that it might also be occurring in the report of subjective sexual arousal. It could be that women are less comfortable than men reporting feeling "turned on" when exposed to sexual stimuli. This could lead to lower concordance rates between subjective and physical sexual arousal in women when compared to men.

To test biases toward socially desirable responses, some researchers have created a procedure called the bogus pipeline, intended to exert pressure on respondents to

answer more truthfully (Roesse & Jamieson, 1993). In the bogus pipeline condition, participants are hooked up to a non-functional lie detector machine and are falsely led to believe that the researcher will detect their deception. It has been shown that the bogus pipeline theory can alter participants' responses in more honest, and less socially desirable ways (Roesse & Jamieson, 1993).

To test how social desirability may affect responses of a sexual nature, Alexander and Fisher (2003) asked participants to report on various sexual behaviors and attitudes including masturbation, number of lifetime sexual partners, and exposure to erotica. To manipulate pressure toward truthfulness, three conditions were created: the exposure condition, in which participants were led to believe that their answers would be seen by a peer (i.e., the research assistant); the anonymous condition, in which participants were told their answers could not be connected to them; and the bogus pipeline condition. Women who believed their answers could be traced back to them reported lower frequencies of masturbation, and lower rates of exposure to erotica (both hardcore and soft-core) in comparison to women in the anonymous and bogus-pipeline conditions. As expected, all women (three conditions combined), reported significantly less incidences of masturbation and exposure to erotica than did men; however, in the bogus pipeline condition, women and men no longer significantly differed in their reports. Although not statistically significant, men reported more sexual partners when they believed their peers were able to read their responses, as well as an earlier age of intercourse than did women ( $p = .08$ ).

Although, to the author's knowledge, no one has used the bogus pipeline condition to investigate how social desirability affects subjective sexual arousal, a recent

study has investigated how social desirable responding may affect women's reports of sexual arousal. In this two-part study, Huberman and colleagues (2013) asked women to rate their level of sexual arousal while viewing either audio or film stimuli. In study one, women were asked to continuously report their sexual arousal towards erotic and neutral audio clips, as well as to report an overall sexual arousal score after each stimulus presentation. In the second study, women were asked to report their sexual arousal to erotic and neutral films prior to, continuously throughout, and directly after the films were presented. In both studies, women also completed a social desirability measure. The authors found that social desirability scores were significantly correlated to discrete (but not continuous) measures of sexual arousal. Thus, the authors concluded that sex researchers should implement continuous measures of sexual arousal to decrease the influence of socially desirable responding in women.

Based on these findings, it seems that men and women do change their responses to questions based on social desirability concerns, although it may be somewhat dependent on methodology. Furthermore, it is possible that, at least in part, sex differences in concordance rates may decrease if study designs move men and women toward more truthful and less socially desirable responding.

**Awareness, feedback loop explanation.** It is possible that subjective experiences of sexual arousal differ as a function of sex because of the anatomical difference between men's and women's genitalia. Although it is well-documented that women experience physical responses in their genitalia (i.e., vaginal lubrication and engorgement of the labia and clitoris) when exposed to sexually arousing stimuli, this is arguably harder for a woman to detect in herself than is a full erection for a man. It is



possible that being able to see and feel bodily changes in response to sexual stimuli serves to increase subjective arousal in a type of feedback loop. Because men can more easily see the physical manifestations of their sexual arousal, they may have a stronger visual-feedback loop than women in terms of physical arousal contributing to subjective arousal.

Perhaps in part related to this feedback loop is the much higher rates of masturbation in men than in women (Petersen & Hyde, 2011). In fact, in a meta-analysis of gender differences in sexuality, (including sexual satisfaction, extramarital sex attitudes, casual intercourse, number of sexual partners, etc.), the largest gender difference between men and women was frequency of masturbation; with men reporting significantly higher frequency of masturbation than women (Petersen & Hyde, 2011). It is possible that because men have more experience with the physical aspects of sexual arousal, as well as more contact with their genitals, it has facilitated a higher concordance of subjective feelings of sexual arousal with its physical manifestations.

In support of this explanation, some evidence has emerged showing that women who are instructed to concentrate on genital changes when assessing their subjective sexual arousal increase their concordance rates between subjective and physical sexual arousal. Specifically, Korff and Geer (1983) conducted a study in which they investigated the impact of an instruction to attend to various physical changes associated with sexual arousal on reports of subjective sexual arousal in 36 women. Participants were either told to focus on genital changes (i.e., vaginal lubrication, pelvic warmth, and/or muscular tension) when rating their subjective sexual arousal to the stimuli; focus on bodily changes (i.e., nipple erection, heart rate, muscular tension, and/or swelling in

the breasts) when rating their subjective sexual arousal; or were not given instructions before viewing the sexual stimuli. Only the participants who were told to focus on their genital changes had significant concordance rates between their subjective and physical sexual arousal.

However, other studies have failed to find similar results. Cerney (1978) investigated how biofeedback might influence women to control their sexual desire. Women were shown erotic videos and their subjective and genital arousal (via vaginal photoplethysmography) was measured. One group received true auditory feedback about their vasocongestive changes; another group received false auditory feedback; while the third group received no feedback. For two trials, participants were instructed to try to increase their sexual arousal, and on one trial they were asked to decrease their sexual arousal. Results showed that women were successful in decreasing their sexual arousal below baseline in the “decrease arousal” condition; however, they were unable to significantly increase their arousal above baseline when instructed to do so. The authors concluded that the biofeedback hypothesis was not supported, and that audio feedback may have actually disrupted participants' arousal. In fact, women who did not receive biofeedback were actually able to increase their sexual arousal during the “increase arousal” condition more than either biofeedback group. Even more interesting, this result seems to be unique to women. Laws and Rubin (1969) found that the four men in their study were able to reduce their erections while watching a sexually explicit film, as well as produce erections when asked to do so (even without watching sexually arousing stimuli or stimulating their penis). This small study tentatively suggests that men may be

able to exert more control over their physical sexual arousal using subjective feelings of arousal than are women.

Because men appear to have practice incorporating their physical sexual arousal into their subjective assessment of sexual arousal, it is likely that this has some effect on their concordance rates between these two measures of sexual arousal. As women do not have as many marked physical cues or as much experience with masturbation, it is likely that their subjective sexual arousal is not as connected to their physical sexual arousal as men. However, considering that giving biofeedback to women has produced inconsistent results in terms of concordance rates between subjective and objective sexual arousal, it is unlikely that this theory fully explains why men and women evidence such marked differences in physical/subjective sexual arousal concordance.

**Cultural effects explanation.** Societal norms appear to have a significant impact on the expression of sexuality. In American culture, specifically, there is evidence that sexual agency and expression is accepted and promoted in men to a much larger extent than it is in women. Men's sexual desires continue to be privileged over those of women. Even in recent studies, women report that their desire to reach orgasm is driven by a will to please their male partners, rather than to please themselves (Nicolson & Burr, 2003) and that their own orgasm is seen as secondary to the man's (Braun, Gavey, & McPhillips, 2003). Furthermore, sex and sexual pleasure is defined primarily by men's preferences (e.g., penile-vaginal intercourse), while women's preferences are typically described as "alternatives" to the norm or as secondary (e.g., foreplay) to the main event of intercourse (Nicolson & Burr, 2003). Consequently, one hypothesis to explain the low concordance rates is that the social suppression of female sexuality has resulted in

women having more conflicted feelings about sexual arousal, possibly resulting in lower subjective arousal scores in test-like situations.

There is a large body of evidence suggesting that women's sexuality is socially and environmentally influenced to a greater extent than that of men. Baumeister (2000) conducted a review of said literature and concluded that women's stated sexual attitudes and behavior appeared to vary, more than do men's, as a function of education, religion, peers, family, and acculturation. For example, women with advanced degrees are more likely to engage in sexual activities like oral or anal sex, engage in same-sex activity, and use birth control, than women with a high-school education. However, this difference in sexual experience is not seen in men as a function of education (Laumann et al., 1994). Another sex difference that Baumeister found in his review of the literature was a significantly larger sexual attitude-behavior inconsistency in women than in men. That is, women are more likely to sexually act in ways that do not conform to their attitudes or beliefs.

In a way, the discordance between subjective and physical arousal that is evidenced in women is parallel to this attitude-behavior inconsistency. If the attitude-behavior inconsistency is a product of the cultural suppression of female sexuality, then maybe so is the concordance. In a male dominated society, women may not only be consciously hiding what they find subjectively arousing; they may have internalized the sexual suppression to the extent that there is reduced or no subjective arousal to stimuli that would have been effective were they in a society more open to female sexual expression. This would constitute the heart of the cultural explanation for the discordance. It is, however, a difficult proposition to subject to empirical investigation.

**Biological adaptation explanation.** A sharply contrasting explanation as to why women show significant physical arousal in the absence of subjective arousal is that the discordance may be an adaptive trait. It is possible that women's non-specific genital sexual arousal constitutes an evolutionary adaptation to facilitate penile penetration even in cases of unwanted or coercive sex. Undesirable as those instances might be, genital engorgement and lubrication would decrease the likelihood of genital injury and/or infection during such sexual activity (Chivers et al., 2007).

In fact, some studies have shown that when women watch forced-sex scenes to which they report low subjective sexual arousal, they still evidence vasocongestion (Both, Everaerd, & Laan, 2003; Laan et al., 1995). Furthermore, genital lubrication in women has been shown to actually precede subjective sexual arousal (Lake Polan et al., 2003). This suggests that vaginal lubrication is an automatic and possibly defensive process to protect women's genitalia from the potential physical damage of unwanted sexual encounters. Therefore, some theorists and researchers have concluded that women's physical sexual arousal as assessed by genital engorgement is a poor indicator of their subjective sexual arousal and it is not likely associated with their sexual preferences, unlike in men (Chivers, 2005).

Explanations for the low concordance between vasocongestion and subjective arousal in women aside, the question remains, 'What does women's subjective arousal concord with?' Is there a non-genital yet objective indicator of sexual arousal that more closely aligns with subjective reports of sexual arousal in women? Visual attention measured via eye-tracking methodology seems like a relevant objective measure that

should align with subjective sexual arousal. After all, visual attention can be theorized to be the first step in the information processing of sexually appealing stimuli.

### **Category Specificity of Visual Attention**

Visual attention has been used for many years to gauge interest in stimuli. More recently, visual attention has been used in sexuality research as an objective measure of sexual interest. The two most common ways to measure visual attention is through the use of eye-tracking instruments that count the number of visual fixations and/or total gaze time on a specific stimulus or scene region.

The first research study to assess visual attention to sexual stimuli was conducted by Rosenzweig in 1942. Participants with schizophrenia were asked to look at photographs of designs, persons in neutral situations, persons in romantic (but non-sexual) scenes, and persons in sexually explicit scenarios. Participants, which were previously categorized as “hyper-sexual” or “low sexual”, were presented with photographs in a photoscope (a large closed box where participants can look at pictures through a looking glass). The participants were allowed to advance pictures at the rate to which they desired by turning a knob connected to the photoscope box. While participants were viewing the pictures, the researcher assessed, via a stopwatch through a one-way mirror, the amount of time the participant viewed the picture before advancing to the next one. Participants in the “hyper-sexual” group stared significantly longer at the sexual photographs than at the non-sexual photographs, while participants in the “low-sexual” group gazed at the sexual and non-sexual photographs equally. Thus, the author concluded, gaze time is a valid measure of sexual interest.

Since then, a number of research studies have incorporated visual attention into sexuality-based research. Rupp and Wallen (2007) asked 15 heterosexual men and 30 heterosexual women (15 of whom were on hormonal contraception) to rate their subjective interest while recording their viewing times of 216 pictures of heterosexual couples engaging in sexual activity. Although men and women did not significantly differ on subjective ratings of sexual interest to the pictures or total viewing time, both men and women gazed more at pictures in which the female was more visible than the male.

Lykins, Meana, and Strauss (2008) tracked the eye movements of 20 heterosexual men and 20 heterosexual women while they were viewing erotic and non-erotic images of couples. Men had more fixations and longer gaze times than women to opposite-sex figures, while women gazed at the same-sex and opposite-sex figures more or less equally. This was true for both erotic and non-erotic images.

In further support of these findings, Israel and Strassberg (2009) asked men and women to rate sexual appeal of nude pictures of men and women while their viewing time was measured unbeknownst to the participants. As seen in prior research, men viewed opposite sex pictures for significantly longer than did women, while women viewed same sex pictures for significantly longer than did men. Men evidenced a category-specific visual response to sexual stimuli, while women showed a more diffuse pattern.

Some research has investigated whether these gender differences in visual attention generalize to video. Tsujimura and colleagues (2009) had 11 men and 11 women view two sexual videos, one depicting sexual intercourse and the other depicting

non-intercourse sexual acts. Although one might imagine that gaze patterns may differ when the stimulus is more dynamic (i.e., a video instead of still images), the results were the same; men viewed opposite sex actors significantly more than did women, and women viewed same-sex actors significantly more than did men. Even more surprisingly, women visually attended to the same sex actor even more than they attended to the opposite sex actor.

More recently, Akhter, Meana, and Lykins (in preparation) conducted a study to investigate category specificity in heterosexual men, women, and androphilic (i.e., attracted to men) MtF transsexuals. Participants were presented with two images on the screen; one of a single nude man and the other of a single nude woman. Both natal men and MtF transsexuals looked significantly longer (i.e. evidenced more fixations and longer gaze duration) towards their erotic target than did natal women. Although women looked at their erotic target longer than at their non-erotic target, their gaze was more diffused across both actors in the scene. Thus, women gazed longer at their non-erotic target than did men or MtF transsexuals.

Much like vasocongestion, visual attention seems to have a clearly gender differentiated pattern. Men visually attend to opposite sex images significantly more than do women, while women visually attend to the same sex images significantly more than do men. Although it is possible that the same explanations for genital vasocongestion apply to visual attention (i.e., women have a less category specific arousal pattern than men), other possibilities may explain why women have a more diffuse gaze pattern than men.



It is possible that women are gazing at female actors for social comparison reasons; prior research has shown that women look at other women for comparison reasons that may be related to their lower body satisfaction in comparison to men (Botta, 1999; Jones & Carlson, 2001; Thompson, Coover, & Stormer, 1999). Another possible explanation is that women have greater empathy than men, and thus are inserting themselves into the image (Rupp & Wallen, 2009). Janssen and colleagues (2003) investigated what aspects of erotic films were inducing sexual arousal in 15 men and 17 women. Participants were asked to view 20 film clips and rate them on a number of dimensions, including how sexually arousing/interesting/repulsive the clip was, how much they identified with the male or female in the clip, and how much attention the participant paid to the male/female actor. For men, 77% of the variance in subjective sexual arousal was dependent on the attractiveness of the female actor in the erotic clip, feeling interested in the film, “imagining oneself as the participant”, and “watching as the observer” in the film. For women, 65% of the variance in subjective sexual arousal was explained by one factor: “imagining oneself as the participant.” Therefore, it might be that women’s arousal is more dependent on being able to place herself into the sexual scene. Of course, this would mean that women do experience some level of arousal from viewing the female actors in the sex scenes.

It is also possible that heterosexual women, in general, are more aroused by erotic images of female actors than heterosexual men are by male actors. Diamond argues that because women can become highly sexually aroused outside of the time frame of potential conception (i.e. ovulation), there would be little benefit for women to exclusively arouse to opposite-sex partners when conception is not possible. However,

because men have the ability to impregnate women throughout the course of the month, it is less advantageous (from a biological standpoint) for men to sexually bond with other men (Diamond, 2006).

Yet another possible explanation is that men have higher levels of homoerotic anxiety when compared to women, and therefore men feel more uncomfortable looking at erotic images of male actors. In fact, Lykins and colleagues (2006) postulated that it is possible that men may be subconsciously averting their gaze from male actors in the images as it may elicit homoerotic anxiety. In an older study, Nevid (1983) assessed homosexual attitudes of 68 heterosexual college men and 65 heterosexual college women after viewing films of homosexual couples engaging in sexual activity. Men expressed more negative attitudes towards homosexuals after viewing the films when compared to women, possibly due to the homoerotic anxiety the men felt. However, as there is little relevant and/or recent literature on the topic, more research is needed in order to fully assess the extent to which men may avoid gazing at erotic images of same-sex stimuli and/or harbor feelings of homoerotic anxiety when compared to women.

Lastly, it is possible that women simply have a more diffused gaze pattern in general, and that it is not specific to sexual stimuli. In fact, Lykins and colleagues (2009) found sex differences in gaze times in both erotic and non-erotic images (men gazing at opposite sex images significantly longer than women, women gazing at same-sex images significantly longer than men). Although non-erotic, fully clothed images of male and female actors may still have some sexual arousal value to participants; it is important to consider that arousal may not be what is driving visual attention in these instances.

Regardless of the explanation, women's visual attention shows the same diffuse pattern as genital vasocongestion. Thus, it is likely that visual attention would yield similar concordance rates with subjective sexual arousal in women as does vasocongestion. So, the question still remains: is there a physiological referent of subjective reports of sexual arousal in women? Perhaps, in the case of women, we will have to go straight to the brain to find it. Even if no other body part reliably indicates subjective arousal, its phenomenological experience would have to emanate from the brain. Using brain activation as a measure of sexual arousal may lead to higher subjective/objective sexual arousal concordance rates, especially in regard to women.

### **Brain Activity and Subjective Sexual Arousal**

**Electroencephalogram/ event related potentials.** Event related potentials (ERPs) are averaged electrical responses evoked in the brain by repeated presentations of stimuli. These electrical responses are collected using an electroencephalography (EEG), which records the summed activity of cortical cells picked up by electrodes placed on various areas on the skull (Gleitman, 1999). Furthermore, ERPs are time-locked to the onset of stimuli. Although not typically used to measure sexual arousal, ERPs can provide insight as to how we differentiate between sexual and non-sexual stimuli before deep processing has even occurred.

Most studies that have investigated sexual arousal using ERPs have found differences between sexual and non-sexual stimuli in the P3 component of the ERP wave. The P3 component occurs approximately 300-500 milliseconds after visual stimuli appear. There is some evidence that the P3 amplitude can become larger when participants are exerting more effort or using more resources on a task (Luck, 2005).

Furthermore, there is evidence in the sex research literature that the P3 component can show sensitivity to valence and emotionality of stimuli (Krug, Plihal, Fehm, & Born, 2000). Some studies have found that P3 amplitude is significantly larger when participants view sexual stimuli vs. non-sexual stimuli (Krug et al., 2000; van Lankveld & Smulders, 2009). In some instances when sexual stimuli were embedded within other pleasant stimuli (e.g., babies or sports events), the P3 amplitude has been shown to be significantly larger for pleasant stimuli (with sexual implants) vs. non-pleasant (and non-sexual) stimuli (Briggs & Martin, 2009; Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000). Therefore, it seems that there is a connection between P3 amplitude and the viewing of sexual stimuli.

Beyond the connection between the P3 component in regards to viewing sexual stimuli, Krug and colleagues (2000) were interested in how women's menstrual cycles affected this connection. Eleven women who had regular menstrual cycles and were not on oral contraception were assessed on three different occasions (during menses, during ovulation, and during the mid-luteal phase) as they viewed sexual pictures of men, babies, females grooming, and ordinary people. After viewing each picture, participants were asked to rate them as either "positive", "neutral", or "negative." ERPs were collected to assess physical sexual arousal. It was found that P3 amplitude was greatest for sexual stimuli compared to all other stimulus categories ( $p < .01$ ). Furthermore, this effect was enhanced during the ovulatory phase of the menstrual cycle ( $p < .01$ ). The authors suggested that these results indicate that participants experienced a more positive valence to the sexual stimuli during the ovulatory phase, which is when there is thought to be an increase in sexual desire.

Although the aforementioned study was conducted exclusively on women, this amplitude increase in P3 component has been shown in men as well. Van Lankveld and Smulders (2009) investigated how arousal and valence might affect picture processing in 16 men. Participants were asked to look at 30 sports photos (e.g., rafting and parachute jumping); 30 high arousal and negative valence photos (e.g., snakes and horror images); 30 low arousal and negative valence photos (e.g., garbage and people crying); 30 sexual pictures (e.g., nude women and couples engaging in intercourse); and 30 low arousal and positive valence pictures (e.g., babies and flowers). Participants were asked to rate every picture on a variety of emotions (including sexual arousal) after each was presented to them on a screen for two seconds. It was expected that the sports and sexual pictures would be equivalent on arousal and valence (i.e., both rated high). However, participants rated sexual photos as significantly more pleasurable than all other conditions ( $p < .001$ ); including the sports stimuli. Furthermore, it was found that P3 amplitude was significantly larger for high arousal pictures than low arousal pictures ( $p < .001$ ). Of more specific interest, there was a significant interaction of valence by arousal, such that P3 for sexual stimuli was larger than what would be expected of high arousal and positive valence alone.

Although most prior research has opted to use visual ERPs in relation to sexual arousal, there has been fruitful research when pairing auditory ERPs with subjective sexual arousal. For example, Vardi and colleagues (2006) found a significant decrease in P3 amplitudes to an auditory distractor tone when participants viewed sexual stimuli versus non-sexual stimuli. This study is particularly noteworthy because, to the author's knowledge, it is the only study that has provided a concordance rate between ERPs and

subjective sexual arousal. In this study, 30 participants (16 women and 14 men) were exposed to visual clips of sports, scenery, and sexual activities. While being exposed to these visual stimuli, auditory stimuli were presented in a random order of low and high tones every two seconds. Low tones indicated the “standard stimulus” while high tones designated the “target stimulus”. Participants were instructed to tap their finger whenever they heard the “target stimulus” and to do nothing when they heard the “standard stimulus” tone. It was hypothesized that there would be a significant decrease in P3 amplitude when participants heard the “target stimulus” sound while viewing sexual stimuli (compared to the “target stimulus” paired with non-sexual stimuli). This is because more attention would be given to the highly-relevant sexual stimuli and would therefore leave less mental resources available to differentiate the “target” or the “standard” stimulus tones. After viewing the stimuli and hearing tones, participants completed a questionnaire that assessed subjective sexual arousal and sexual interest. As expected, P3 amplitude decreased significantly when target tones were presented while viewing sexual stimuli when compared to viewing nonsexual stimuli ( $p < .0001$ ). Interestingly, the degree to which the P3 amplitude decreased was significantly related to sexual arousal scores ( $r = .61, p < .001$ ) and level of interest scores ( $r = .37, p < .05$ ); critically, the later correlation was not found with other (non-sexual) stimuli and interest scores.

These results lend support to the argument that the significant decrease in the P3 component reflects sexual arousal in individuals. Lastly, it was reported that men and women did not evidence a significant difference in P3 amplitude decrease when viewing sexual stimuli as well as no significant differences in correlations between P3 amplitude

decreases and subjective arousal. This is particularly of interest, as most other objective measures of sexual arousal show marked sex differences. Based on this study (and the ones previously mentioned), it seems that for both men and women, there is a connection between the P3 component and the processing of sexual stimuli.

Beyond P3 amplitude, other components of ERPs have been shown to significantly differ upon exposure to sexual stimuli versus non-sexual stimuli. The late positive component (or “LPC”), which is approximately 500-700 milliseconds after the stimulus appears, has shown significant changes when participants are viewing sexual stimuli. Like the P3, the LPC have been shown to indicate emotionality and valence to a stimulus; however the LPC portion of the ERP seems to better discriminate between neutral and affective stimuli than does the P3 portion (Johnston, Miller, & Burleson, 1986; Krug et al., 2000). Van Lankveld and Smulders (2009; details discussed previously) found that the LPC appeared to be larger after participants’ viewed sexual stimuli when compared to non-sexual stimuli, but only during the ovulatory phase ( $p < .05$ ). Furthermore, other studies have found significant increases in amplitude in the LPC when viewing sexual vs. non-sexual stimuli (Krug et al., 2000), or for emotionally valenced images (which include erotic images; Anokhin, Golosheykin, Sirevaag, Kristjansson, Rohrobaugh, & Health, 2006; Cuthbert et al., 2000). However, more research is needed to understand how LPC may relate to the processing of sexual stimuli and whether participants process sexual stimuli differently from other positive (or highly valenced) stimuli.

The P2 component has also been investigated in relation to sexuality and the processing of sexual images. The P2 component (which appears approximately 250

milliseconds after visual stimuli are presented) can indicate rapid categorization of complex scenes and discrimination between distinct content categories (Anokhin et al., 2006). Anokhin and colleagues (2006) asked 132 female twins to view photographs, including erotic pictures (e.g., nude couples), positive non-erotic pictures (e.g., sports and entertainment scenes), neutral pictures (e.g., household objects), and negative pictures (e.g., weapons). Subjective sexual arousal was not assessed in this study. ERP results showed that when participants were viewing erotic pictures, the P2 amplitude significantly increased when compared to non-erotic stimuli. Furthermore, the negative peak (N4, the component that appears approximately 375-600 milliseconds after stimuli are presented) was significantly suppressed compared to ERPs displayed during other non-erotic stimuli. The authors suggest that these changes in the P2 and N4 amplitude may denote “early” processing, and this perhaps suggests that there is a neuronal network that prioritizes rapid processing of highly biological, adaptive, and/or evolutionary relevant stimuli (i.e., sexual stimuli).

Another possible area of interest is the N1 auditory component of the ERP. N1 is sensitive to, and can be influenced by, attention (Luck, 2005). However, to the authors' knowledge, only one known study has investigated the effects of sexual arousal on attention via auditory ERPs, and no mention of N1 auditory component was made in this study (Vardi et al., 2006). Therefore, the relationship between the auditory N1 component of the ERP and subjective sexual arousal remains unknown. It seems that more research is needed to understand the connection between subjective sexual arousal and brain activation via ERPs.

### **Current Research Study**



Prior research in genital arousal and visual interest has illustrated a pattern of female vasocongestion and visual attention that does not discriminate between subjectively arousing stimuli. However, when using ERPs as a physical sexual arousal measure, women's brain activity appears to be more closely aligned with reports of subjective sexual arousal (i.e., category specificity). In the current study, we aimed to investigate the extent to which ERPs, more specifically the auditory N1 and P3 component, aligned with subjective reports of sexual arousal in both men and women. In this study, participants were exposed to auditory stimuli presented while viewing erotic stimuli. In this study, participants viewed two films while being asked to make judgments on auditory stimuli. One film was of a heterosexual couple engaging in sexual acts, and the second was of a man and woman cooking. Periodically, participants rated (on a scale of one to seven) their level of excitement, sexual arousal, boredom, and disgust toward the videos. Our hypotheses for the study were as follows:

**Hypothesis #1.** Men will report significantly higher subjective sexual arousal than women while watching the erotic film.

**Hypothesis #2a.** As the auditory odd-ball paradigm is intended to distract the participant from the highly-relevant sexual stimuli, men will evidence significantly smaller auditory N1 amplitude than women when viewing the sexually explicit clip.

**Hypothesis #2b.** Men will also evidence significantly smaller auditory P3 amplitude than women when viewing the sexually explicit clip.

**Hypothesis #3a.** Men's and women's auditory N1 amplitudes will significantly and positively correlate with their score on the subjective sexual arousal question for the erotic film.

**Hypothesis #3b.** Men's and women's auditory P3 amplitudes will significantly and negatively correlate with their score on the subjective sexual arousal question for the erotic film.

For both N1 and P3 amplitudes, we did not expect any gender differences in the magnitude of the correlations.

## CHAPTER 3

### METHODOLOGY

#### **Participants**

This study was approved by the International Review Board of the University of Nevada, Las Vegas. Participants were recruited through the subject pool at the University of Nevada, Las Vegas, as well as through the use of snowball techniques. To be eligible for this study, participants had to self-identify as heterosexual (i.e., assessed via the Kinsey Scale), be at least 21 years of age, and report to have had sex at least once in their lifetime. Although being sexually active was not a requirement to be a part of the study, the sexual function of participants who had been sexually active in the last four weeks was assessed. Of these participants, only those with normal sexual function scores were included in the study. When participants reported they were not sexually active in the last four weeks, sexual function was not assessed. A total of 49 men and women participated in the study. After excluding participants with unusable EEG data (n=6), those who did not report being heterosexual (n=3), those who scored lower than the acceptable range on the sexual function scale (n=1), and those who missed too many “target” tones (n=1), the total number of participants was 38.

Table 2 presents the demographic characteristics of the participants in the study. Participants were around 26 years old, and all were either currently in college or had a bachelor’s degree or higher. In terms of relationship status, most participants reported that they were single and dating or single and not dating. Just over half of the sample identified as European-American/Caucasian and a large majority reported being sexually active in the last four weeks. Furthermore, most participants identified as either

Catholic/Christian or as having no religious affiliation. All but one participant reported they had viewed pornography in their lifetime, and most had viewed erotica on a somewhat regular basis (i.e., viewing pornography monthly, weekly, or daily). Average pornography consumption was roughly equivalent to monthly watching.

Table 2

*Demographic Characteristics of Participants (N=38)*

Characteristics	<u>N</u> ( <i>M</i> )	% ( <i>SD</i> )
Gender		
Female	19	50.00
Male	19	50.00
Age	(26.55)	(5.65)
Relationship Status		
Single and Not Dating	9	55.26
Single and Dating	14	36.84
Have a Steady Partner	6	15.79
Cohabiting/Married	8	21.05
Divorced	1	2.63
Education		
Some College	21	55.26
College Degree	12	31.58
Graduate Degree	5	13.16
Self Identified Ethnicity		
African American	3	7.89
Asian American	6	15.79
European American	21	55.26
Latino	4	10.53
Other	4	10.53
Self-Identified Religion		
Catholic/Christian	17	44.74
No Religion	17	44.74
Other Religion	4	10.52
Currently Sexually Active		
Yes	34	89.47
No	4	10.53
Pornography Consumption	(2.89)	(1.35)
Never	1	2.63
Less than 10 times ever	6	15.79
Less than once a month	8	21.05
Monthly	8	21.05
Weekly	11	28.95
Daily	4	10.53

## Stimuli

**Visual stimuli.** The visual stimuli consisted of two films without audio that participants viewed in a counterbalanced order: the erotic film titled *Sweet Lady*, and a non-erotic film of a couple cooking. *Sweet Lady* has been previously validated at the Kinsey Institute as eliciting the highest subjective sexual arousal collectively in both men and women, among a large set of erotic videos (Jenssen, 2003). The film of the couple cooking was intended to depict a non-sexual activity performed by a man and a woman together. Each film was presented in sequential 40-second segments. A total of 15 of these 40-second segments were used for a total duration of 10 minutes of the erotic film and 10 minutes (or 15 segments) of the cooking film.

**Auditory stimuli.** While participants were viewing the stimuli, two tones were presented, 500 and 1,560 Hz tones with a 0.05-millisecond rise/fall and a 5-millisecond plateau. An oddball paradigm was implemented; tones were presented every 2 seconds in random order, with the 500 Hz tones designated as the standard tones and 1,560 Hz tones designated as the target tones. Standard tones were presented 80% of the time while target tones were presented 20% of the time. A minimum of two standard tones was presented between target tones, and the first and last tones in each 40-second segment were never target tones. Thus, a total of four target tones were presented in each 40-second set. These stimuli were adapted from research conducted by Vardi and colleagues (2006).

## Measures

**Demographic questionnaire.** Demographic information was collected to assess age, ethnicity, sexual orientation, socioeconomic status, education, pornography

exposure, and gender, along with other relevant background information (see Appendix I).

**Kinsey heterosexual-homosexual scale (Kinsey et al., 1948).** Sexual orientation was assessed via the Kinsey Scale. The scale ranges from *0 = exclusively heterosexual* to *6 = exclusively homosexual*. Only participants who endorse a *0* or *1* on the Kinsey Scale were included in subsequent analyses (see Appendix II).

**Subjective emotions questionnaire.** After each 40-second film segment (erotic or cooking) was presented, participants answered the following questions on the computer screen, “To what extent did the film elicit the following emotions in you?” Emotions assessed were excitement, sexual arousal, boredom, and disgust. Answer choices ranged from (1) *not at all* to (7) *very much* (see Appendix III). This is an adaptation of the questionnaire used by Vardi and colleagues (2006).

**Sexual function questionnaire.** Two different sexual function questionnaires were used in this study, one for men and one for women.

**Female sexual function index (FSFI; Rosen et al., 2000).** The FSFI is a multidimensional self-report survey that consists of 19 Likert-scale items that assess female sexual function over the past four weeks in six areas: arousal, sexual desire, orgasm, lubrication, satisfaction, and pain. This measure has been previously validated on both clinical and non-clinical populations (Leiblum & Seehuus, 2006; Meston, 2003; Wiegel, Meston, & Rosen, 2005; Ter Kuile, Brauer, & Laan, 2006). It has been shown to have excellent internal consistency and adequate test-retest reliability, and is highly recommended as a diagnostic tool for women (Meana, Binik, & Thaler, 2008). Female participants who had sexual relations in the last four weeks and a score lower than 26.55

(indicating sexual dysfunction) were excluded from the analyses (Wiegel, Meston, & Rosen, 2005; see Appendix IV). Those who reported no sexual activity in the last four weeks were not screened based on this scale. For the sexually active women in this study's sample, the internal consistency was assessed via Cronbach's alpha, and was .66.

**International index of erectile function (IIEF; Rosen et al., 1997).** This measure consists of 15 Likert-scale items that assess different areas of male sexual function; orgasmic function, erectile function, sexual satisfaction, and sexual desire. As with the FSFI, this measure has been previously validated with clinical, non-clinical, and multiple ethnic populations (Ramanathan et al., 2007; Reis & Abdo, 2010; Weiss & Brody, 2011). For sexual function assessment of men, the IIEF is the leading diagnostic tool recommended (Meana, Binik, & Thaler, 2008). Male participants that were sexually active in the last four weeks and scored 25 or less (indicating sexual dysfunction) were not included in subsequent analyses (Rosen, Cappelleri, & Gendrano, 2002; see Appendix V). Those who reported no sexual activity in the last four weeks were not screened based on this scale. For the sexually active men in this study's sample, the internal consistency was assessed via Cronbach's alpha, and was .91

## **Procedure**

Electroencephalographic (EEG) signals were digitized continuously (512 Hz sampling rate and a 104 Hz bandwidth) using a Biosemi Active Two system (<http://www.biosemi.com>). The EEG recorded on an array of 72 electrodes, with a Common Mode Sense (CMS) active electrode and Driven Right Leg (DRL) passive electrode serving as ground (see <http://www.biosemi.com/faq/cms&drl.htm>), placed at 64 points based on the 10/20 system in a Biosemi electrode cap and 8 additional points



below the hair line (both mastoids, both pre-auricular points, outer canthus of each eye, and inferior orbit of each eye) and recorded onto a PC desktop computer for offline analysis. No abrading of the skin was performed. Voltage offsets were below 25 mV prior to recording, and the resting EEG was checked for any problematic electrodes prior to and throughout the recording.

During the experiment, participants were asked to read and sign a consent form in the laboratory at UNLV. Prior to the placement of the EEG electrodes, a hearing test was conducted to assess whether the participant's hearing was within a normal range. Once it was deemed that their hearing was sufficient for the study, sintered Ag-AgCl pin-type electrodes were placed on each participant's head and conducting gel was applied to the skin at each electrode site with the cap on, while electrodes were fit into place at each site in the cap. For the eight points below the hairline, Ag-AgCl flat-type electrodes were attached with adhesive. Research assistants then escorted participants into a private room with a computer, and specialized 3A audiometric insert earphones from E-A-RTONE were placed in their ears. Resting EEG was checked for any problematic electrodes prior to and throughout the recording session. Then, participants went through a trial run in which the tones were played repeatedly in order to ensure they felt comfortable with identifying target tones and standard tones.

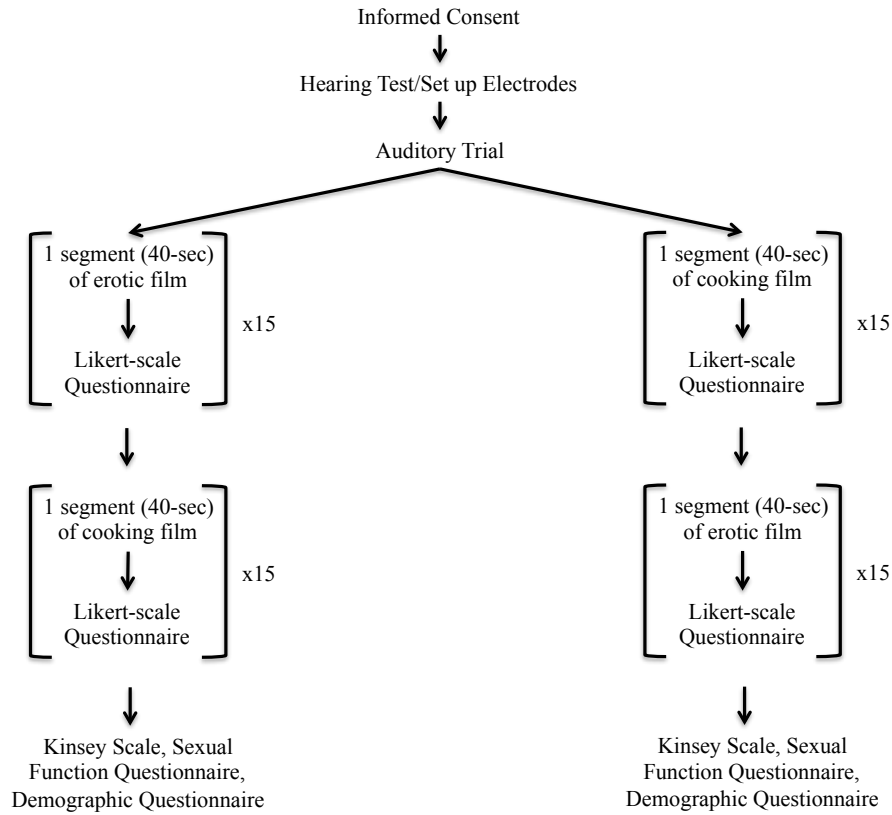
Once the participant felt that he/she could adequately distinguish the target and standard tones, the study began. The participant was instructed to pay attention to the film segments that appeared on the screen while pressing the spacebar when he/she heard a target tone. Participants were asked to make a judgment for the target stimuli so that it would evoke a P3 response in their ERP (Luck, 2005). They were also instructed that a

questionnaire asking them to rate how they felt on a set of emotions would be presented every 40-seconds. To deter social desirability, participants were deceived to believe that the EEG machine could act as a lie detector machine, so they should answer the subjective emotions questions as honestly as possible, as we would compare their responses with the results of the EEG machine. After the instructions, participants were presented with either the erotic or cooking 40-second film segments. After the segment (or 40-seconds of the film) was presented, the participant completed the Likert-Scale questionnaire on the computer assessing his/her feelings about what was seen. The next 14 segments of the film were presented in the same fashion until the entire film was viewed, tones were heard, and all answers to the Likert-Scale questions were collected. After the film was viewed in its entirety, this same process was repeated for the second 15-segment film. Once both films were viewed, the participant was asked to complete the demographic questionnaire, the Kinsey Scale, and the gender-specific sexual function questionnaire on a computer. In total, the study took approximately 90 minutes to complete.

Participants were not debriefed on the deception in this study immediately after participating for two reasons: first, the amount of deception was minimal and not expected to cause significant distress; and second, there was concern that debriefing participants after the study may lead to future participants having knowledge of the deception, which would have greatly affected the validity of the study. Instead, after all participants completed the study, an email was sent explaining the deception and allowing participants to withdraw their data from the study if they so choose. No participants opted to withdraw from the study after knowledge of the deception.

Furthermore, information was collected on the amount to which participants believed that the EEG was able to detect the truthfulness of their responses to the emotion questionnaires. Over 89% of participants believed that the EEG could at least “somewhat” detect the truthfulness of their responses (i.e. reporting 4 or above on a 1-7 point Likert scale). Furthermore, there were no significant gender differences in these reports.

Figure 1. Procedures for Study



**EEG data analysis.** All off-line ERP analyses were performed using Brain Electrical Source Analysis software (BESA, MEGIS Software GmbH, Gräfelfing, Germany). Electrodes that were noted during the recording as being noisy throughout the experiment were interpolated prior to analysis. Ocular artifacts (blinks, saccades, and smooth movements) were corrected automatically with a Principal Component Analysis method. Epochs contaminated by artifacts (amplitude > 150 uV, gradient > 75 uV, low signal < 0.01 uV) were automatically rejected before averaging. Individuals were first averaged separately before a grand average was computed. EEG epochs were averaged separately across all nonartifact trials for the different tone types, and the different film types (i.e., cooking film standard tones, cooking film deviant tones, erotic film standard

tones, erotic film deviant tones). There were a total of 240 standard tones per film type and 60 deviant tones per film type (i.e. cooking film and erotic film). ERPs during the contexts were measured by averaging EEG epochs for each stimulus condition and electrode site separately, and rereferencing to the average of all electrodes not adjacent to the eyes. An average of 86% of the trials for each participant was accepted, with a range of 57% to 100%. Epochs were analyzed 100 ms prior to stimulus onset and continued 1000 ms after onset. ERPs were filtered to attenuate frequencies below .5 Hz (6 dB/octave attenuation, forward) and above 30 Hz (24 dB/octave attenuation, zero phase). ERP amplitudes were measured relative to the mean amplitude over the 100 ms prestimulus interval.

ERP mean amplitudes were calculated in time ranges showing maximal differences in the grand-averaged waveforms between areas of interest at electrodes showing the maximal difference. Prior to ERP component and electrode selection, the grand average of participants (both men and women combined) was used for analysis. This was done so that the time-range and electrode site definitions of ERP components were the same across gender, and to ensure that data was not pre-selected to artificially inflate possible gender differences in ERP amplitudes. ERP components were visually identified and time ranges were selected where the ERP amplitudes were maximal. Electrodes were chosen in the same manner. For the N1 component, the time range chosen was 90-115 milliseconds, and for the P3 component the time range chosen was 385-600 milliseconds. After time ranges and areas of interest were chosen, grand averages of men and grand averages of women were assessed separately to insure that the maximal peaks were captured for both genders. Mean amplitudes were averaged across a

set of electrodes for each component; the N1 amplitude was averaged from the electrodes in the frontal area (FC1, FZ, FC2), the central area (C1, CZ, C2), and the central-parietal area (CP1, CPZ, CP2); the P3 amplitude was most prominent in the parietal area (P1, PZ, P2) and the parietal-occipital area (PO3, POZ, PO4) and therefore these were the six electrodes averaged for the subsequent analyses of the P3 amplitude (see Figure 2 for ERP waveforms and Figure 3 topographies of waveforms). As there were no significant differences found between the N1 amplitudes for standard and deviant tones, both tones were included in the averaged wave-forms for future N1 component analyses. For the P3 component, only deviant tones were analyzed.

## CHAPTER 4

### RESULTS

#### Covariation

Sociodemographic variables and pornography use were assessed for possible covariation with gender. Only pornography consumption evidenced a gender difference (with men viewing significantly more pornography than women), and thus, was added to subsequent analyses wherever possible, ( $M = 3.53$ ,  $SD = 1.17$  vs.  $M = 2.26$ ,  $SD = 1.24$ ),  $F(1,36) = 10.41$ ,  $p < .01$ ,  $\eta_p^2 = .22$ . Three separate one-way ANOVAs were also conducted to determine if the order of film presentation had any impact on the three dependent variables (subjective sexual arousal, N1 amplitude, and P3 amplitude). Differences in subjective sexual arousal between the two order of film presentations were evidenced such that participants who viewed the erotic film first reported greater subjective sexual arousal overall than participants who viewed the cooking film first ( $M = 3.10$ ,  $SD = 0.69$  vs.  $M = 2.39$ ,  $SD = 0.79$ ),  $F(1, 36) = 8.66$ ,  $p < .01$ ,  $\eta_p^2 = .19$ . We decided to treat order of film presentation as a third factor in our analyses because of its impact on subjective sexual arousal and prior research that has illustrated that repeated presentations of tones reduce N1 and P3 amplitudes (Luck, 2005; Romero & Polich, 1996; Rosburg, 2004). For clarity purposes, we will denote order henceforth as *Order CE* (the cooking film presented first followed by the erotic film) and *Order EC* (the erotic film presented first followed by the cooking film). Lastly, recruitment type (subject pool vs. word-of-mouth recruitment) was investigated in order to determine there were any differences in participants based on how they were approached to enter the study. There were no differences in age, percent paying attention to the erotic film, or pornography

consumption based on recruitment type. Furthermore, a 2 (recruitment type- subject pool vs. word-of-mouth) by 2 (gender) MANOVA on the three dependent variables (subjective sexual arousal, N1, or P3 ERP components) was conducted in order to determine if there was a main effect of recruitment type, or an interaction of recruitment type by gender on any of the dependent variables. There was none. Thus, it was decided to leave recruitment type out of further analyses.

### **Distribution of the Dependent Variables**

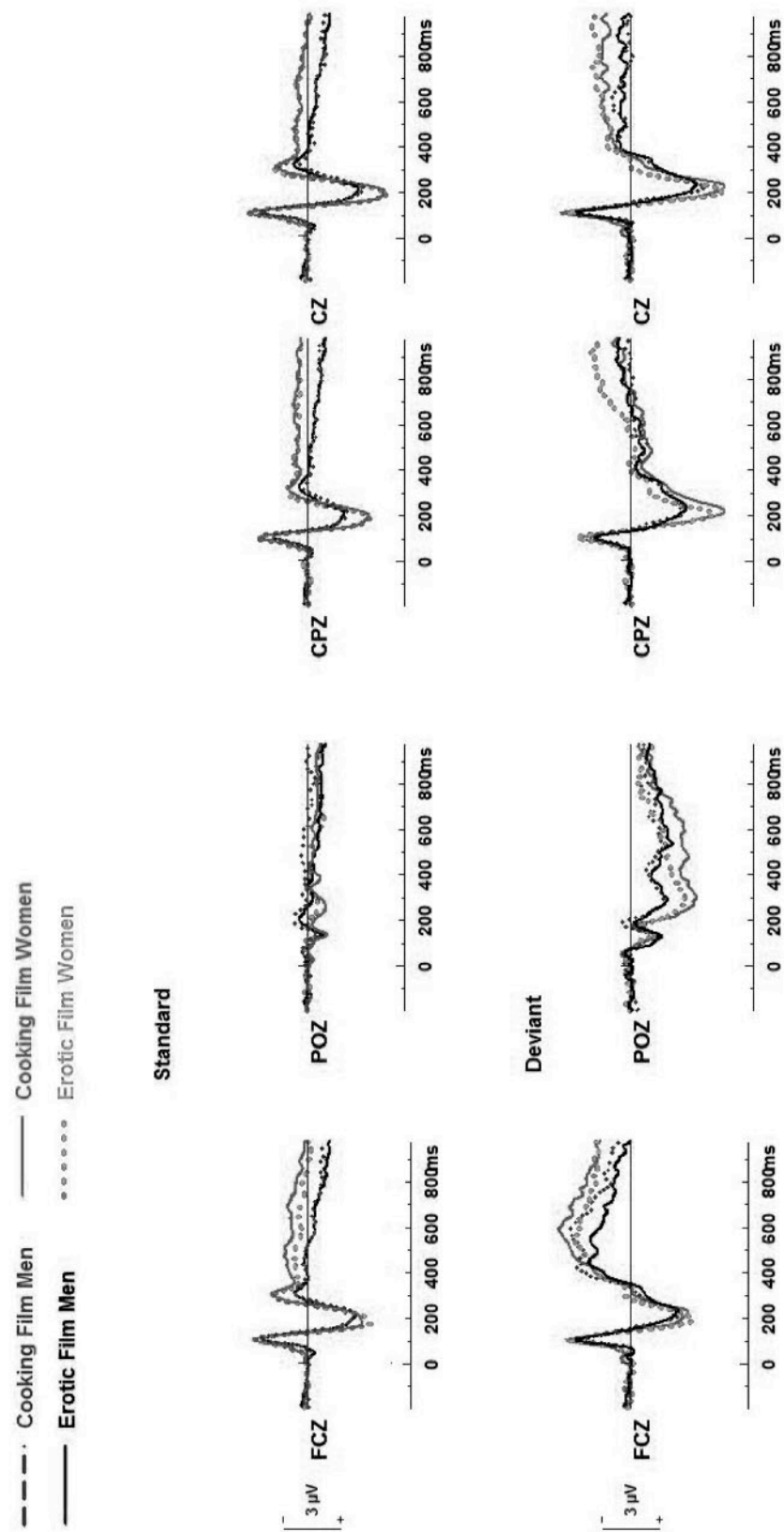
The N1 and P3 amplitudes of the auditory ERP and subjective reports of sexual arousal were the dependent variables. Please refer to Figure 2 for ERP waves separated by gender and film type and Figure 3 for ERP topographies for the wave forms again separated by gender and film type.

Skewness and kurtosis were examined for each dependent variable in order to investigate whether any assumptions had been violated concerning the ANCOVAs. Please refer to Table 2 for the means and standard deviations of the dependent variables. The N1 component was positively skewed (skew = 1.09, kurtosis = 2.02). The P3 component was also positively skewed but to a lesser degree than the N1 component (skew = .24, kurtosis = -1.04), and the subjective sexual arousal data was slightly negatively skewed (skew = -.24, kurtosis = -.91). With all of the dependent variables, the skewness was divided by the standard error of the skewness in order to determine if the dependent variables were so highly skewed that further steps were needed. For all of the dependent variables that number was below three, which is considered an acceptable level of skewness (Tabachnick & Fidel, 2007). Therefore, no action was taken to reduce the skewness of the dependent variables.

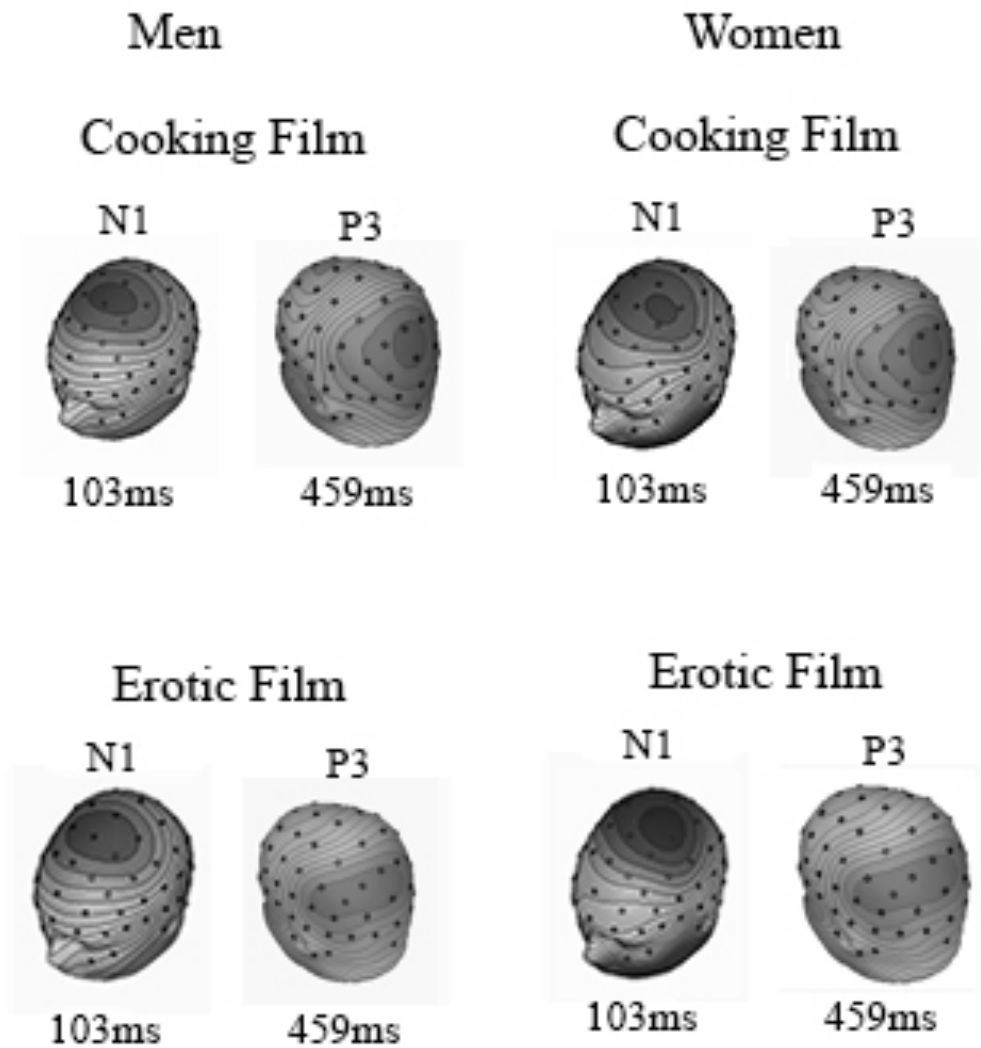


Possible outliers were also assessed for all dependent variables. Three possible outliers were found with data points two standard deviations above or below the mean (one possible outlier in regards to the P3 amplitude, and two possible outliers in regards to the N1 amplitude). All analyses were conducted without these three participants, and results did not differ from when participants were included. Thus, it was decided not to remove any of the three participants from the analyses.

Figure 2. Event Related Potential (ERP) Results as a Function of Gender and Film Type



*Figure 3.* Topographies of the ERP Waveforms Elicited During 103ms (N1) and 459ms (P3) as a Function of Gender and Film Type



## **Hypothesis Testing**

**Hypothesis #1.** *Men will report significantly higher subjective sexual arousal than women while watching the erotic film.*

This hypothesis was tested via a 2 (gender) x 2 (film type [erotic/cooking]) x 2 (order [Order CE/Order EC]) mixed-design ANCOVA (CV- pornography consumption). Responses to the question “To what extent did the film elicit sexual arousal in you?” were averaged across the 15 segments in each film type to arrive at a total subjective sexual arousal score for the erotic film and a total subjective sexual arousal score for the cooking film per participant (see Table 3 for means and standard deviations).

Table 3

*Means and SDs for Women and Men: Subjective Reports/ERP Amplitudes as a Function of Order and Film Type (Means Adjusted Based on Covariate Pornography Consumption)*

	Male Participants ( $n = 19$ )						Female Participants ( $n = 19$ )						Male and Female Combined ( $n = 38$ )					
	Order CE		Order EC		Combined		Order CE		Order EC		Combined		Order CE		Order EC		Combined	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Subjective Sexual Arousal																		
Cooking film	1.01	0.24	1.05	0.25	1.03	0.26	1.18	0.27	1.32	0.25	1.25	0.26	1.09	0.27	1.19	0.25	1.14	0.25
Erotic film	2.85	1.35	4.58	1.45	3.72	1.44	4.46	1.39	5.41	1.39	4.93	1.44	3.66	1.34	5.00	1.36	4.33	1.36
Both films	1.93	0.69	2.82	0.73	2.37	0.74	2.82	0.70	3.36	0.71	3.09	0.74	2.37	0.67	3.09	0.68	2.73	0.68
N1 Amplitude																		
Cooking film	-2.99	1.35	-1.74	1.58	-2.37	1.44	-2.48	1.39	-2.39	1.41	-2.43	1.48	-2.73	1.34	-2.06	1.36	-2.40	1.36
Erotic film	-2.94	1.38	-1.79	1.49	-2.36	1.48	-2.08	1.43	-2.81	1.44	-2.45	1.48	-2.51	1.39	-2.30	1.40	-2.40	1.42
Both films	-2.94	1.35	-1.76	1.45	-2.36	1.44	-2.28	1.39	-2.60	1.41	-2.44	1.44	-2.62	1.34	-2.18	1.36	-2.40	1.36
P3 Amplitude																		
Cooking film	1.27	1.35	0.77	1.42	1.02	1.44	2.54	1.36	1.65	1.39	2.10	1.44	1.91	1.34	1.21	1.32	1.56	1.36
Erotic film	1.25	1.38	1.71	1.45	1.48	1.44	1.75	1.39	0.93	1.41	1.34	1.48	1.50	1.39	1.32	1.36	1.41	1.36
Both films	1.26	1.11	1.24	1.20	1.25	1.18	2.15	1.16	1.29	1.16	1.72	1.22	1.71	1.12	1.27	1.10	1.49	1.11

Hypothesis #1 was not confirmed. As reported in Table 4, although there was a trend for a film type by gender interaction, it was not in the expected direction,  $F(1,33) = 3.77, p = .06, \eta_p^2 = .10$  (see Figure 4). Simple effects analyses of gender indicated that women rated the cooking film,  $p = .03$ , and the erotic film,  $p = .04$ , as more sexually arousing than did men. Simple effects analyses of film type indicated that both men and women rated the erotic film as more arousing than the cooking film,  $p = .04$  for men,  $p = .02$  for women. Other non-hypothesized results of this ANCOVA were as follows:

As reported in Table 4, there was a significant main effect of gender: women reported higher levels of subjective sexual arousal than men,  $F(1,33) = 8.25, p < .01, \eta_p^2 = .20$ . There was also a significant main effect of order such that, when participants viewed films in Order EC, they reported more sexual arousal than when participants viewed films in Order CE,  $F(1,33) = 10.68, p < .01, \eta_p^2 = .25$ . Lastly, there was a significant main effect of film type with participants reporting more sexual arousal to the erotic film than to the cooking film,  $F(1,33) = 10.51, p < .01, \eta_p^2 = .10$ .

There were also non-hypothesized interactions. As reported in Table 4, a significant interaction between film type and order was also found,  $F(1,33) = 7.69, p < .01, \eta_p^2 = .19$  (see Figure 5). Simple effects analyses revealed that there was an effect of order such that participants who viewed films in Order EC reported more sexual arousal to the erotic film than participants who viewed films in Order CE,  $p = .01$ . There was also significant simple effects of film type; participants reported the erotic film as significantly more sexually arousing than the cooking film when viewing films in either order; CE,  $p < .01$ ; EC,  $p < .01$ .

Table 4

*Mixed-Design Analysis of Covariance of Subjective Sexual Arousal as a Function of Gender, Film Type, and Order, with Pornography Consumption as a Covariate*

Source	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>	$\eta_p^2$
<i>Between Subjects</i>					
Porn Consumption (CV)	4.78	1	4.78	5.32*	.14
Gender	7.41	1	7.41	8.25**	.20
Order	9.60	1	9.60	10.68**	.25
Gender x Order	.55	1	.55	.61	.02
Error 1	29.66	33	.90		
<i>Within Subjects</i>					
Film Type	9.94	1	9.94	10.51**	.10
Film Type x Porn Consumption (CV)	4.65	1	4.66	4.92*	.13
Film Type x Gender	3.57	1	3.57	3.77 <sup>a</sup>	.10
Film Type x Order	7.28	1	7.28	7.69**	.19
Film Type x Gender x Order	0.89	1	.89	.95	.03
Error 2	31.24	33	.95		

\*\* $p < .01$ , \* $p < .05$ , <sup>a</sup> $p < .10$

Figure 4. Subjective Sexual Arousal as a Function of Gender and Film Type

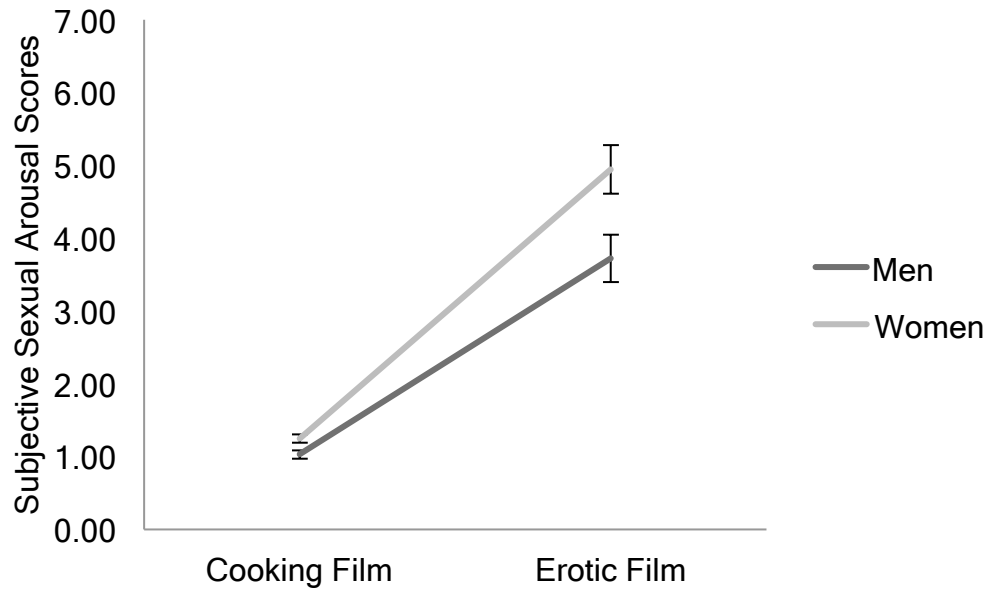
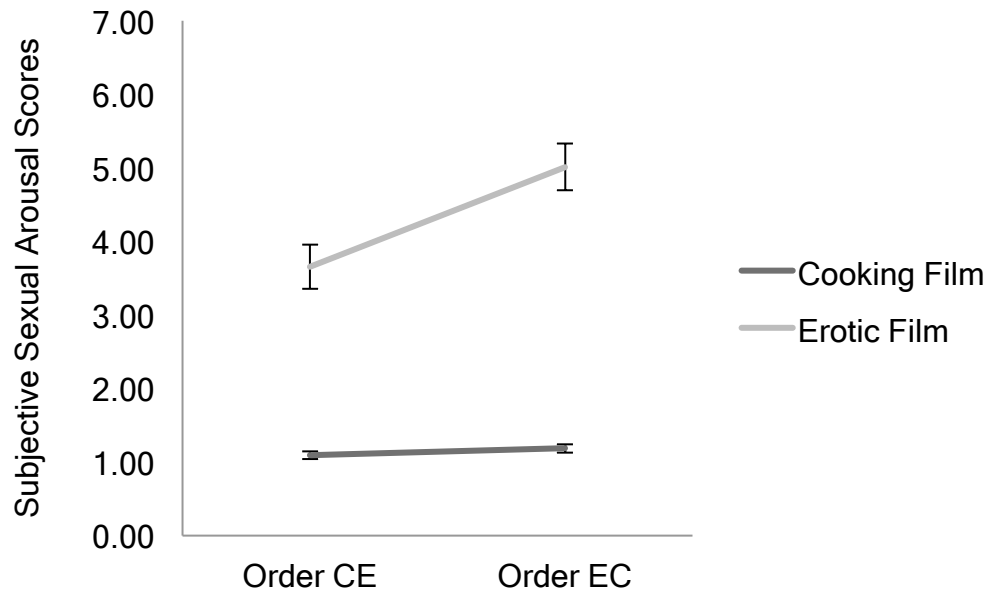


Figure 5. Subjective Sexual Arousal as a Function of Film Type and Order





**Hypothesis #2a.** *As the auditory odd-ball paradigm is intended to distract the participant from the highly-relevant sexual stimuli, men will evidence a significantly smaller auditory N1 amplitude than women when viewing erotic clip.*

**Hypothesis #2b.** *Men will evidence a significantly smaller auditory P3 amplitude than women when viewing the erotic clip.*

**Hypothesis #2a.** This hypothesis was tested via a 2 (gender) x 2 (film type [erotic/cooking]) x 2 (order [Order CE/Order EC]) mixed-design ANCOVA (covariate-pornography consumption). In order to calculate the dependent variable, N1 amplitudes were averaged across the 15 video segments per film, to obtain two averaged N1 amplitude scores for each participant (i.e., an averaged N1 amplitude score for the erotic film and an averaged N1 amplitude score for the cooking film). It is important to note that the N1 component is negative, so less negative numbers denote smaller N1 amplitudes (see Table 3 for means and standard deviations).

Hypothesis #2a was not confirmed, as the film type by gender interaction was not significant. Other non-hypothesized analyses are reported henceforth.

As reported in Table 5, there was a trend toward a significant interaction between gender and order on the N1 amplitude,  $F(1,33) = 2.95, p = .09, \eta_p^2 = .08$  (see Figure 6).

There was a significant interaction between film type and order,  $F(1,33) = 7.62, p < .01, \eta_p^2 = .19$  (see Figure 7). Although no simple effects were significant, there was a trend

toward a simple effect of film type in Order EC, as participants evidenced smaller N1 amplitudes in the cooking film vs. the erotic film,  $p = .10$ . Lastly there was a

significant film type by gender by order interaction,  $F(1,33) = 4.65, p = .04, \eta_p^2 = .12$  (see Figure 8). A significant simple main effect of order was found such that men evidenced

smaller N1 amplitudes when films were presented in Order EC when compared to Order CE when viewing the erotic film,  $p = .04$ , and the cooking film,  $p = .04$ .

Table 5

*Mixed-Design Analysis of Covariance of Auditory N1 Amplitude as a Function of Gender, Film Type, and Order, with Pornography Consumption as a Covariate*

Source	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>	$\eta^2_p$
<i>Between Subjects</i>					
Porn Consumption (CV)	25.58	1	25.58	1.79	.05
Gender	.34	1	.34	.02	.00
Order	14.39	1	14.39	1.01	.03
Gender x Order	42.14	1	42.14	2.95 <sup>a</sup>	.08
Error 1	471.50	33	14.29		
<i>Within Subjects</i>					
Film Type	.07	1	.07	.53	.02
Film Type x Porn Consumption (CV)	.08	1	.08	.58	.02
Film Type x Gender	.00	1	.00	.01	.00
Film Type x Order	.99	1	.99	7.62**	.19
Film Type x Gender x Order	2.41	1	2.41	4.65*	.12
Error 2	4.27	33	.13		

\*\* $p < .01$ , \* $p < .05$ , <sup>a</sup> $p < .10$

Figure 6. N1 Amplitude as a Function of Gender and Order

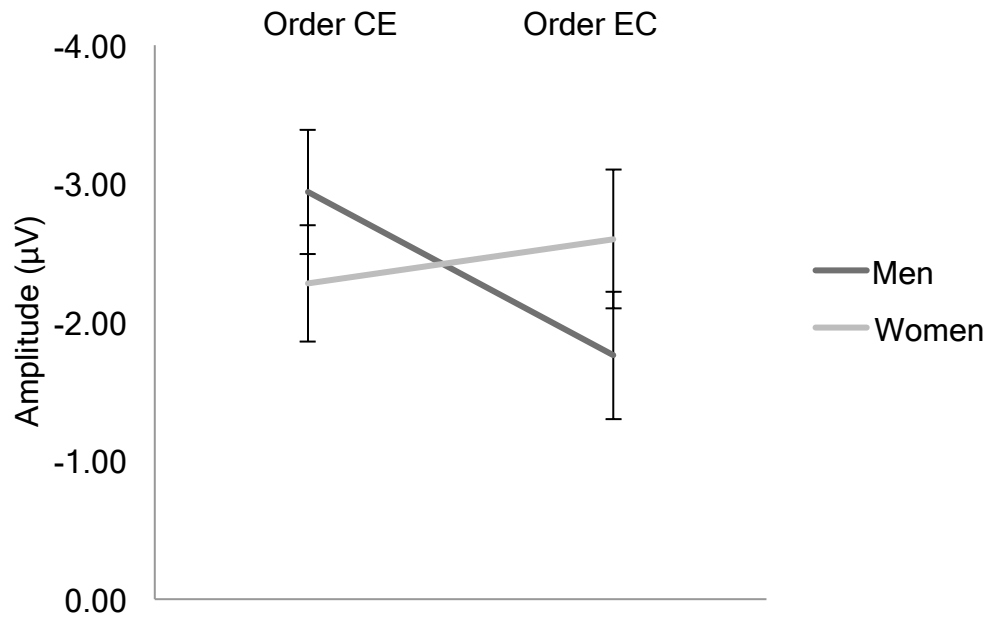


Figure 7. N1 Amplitude as a Function of Film Type and Order

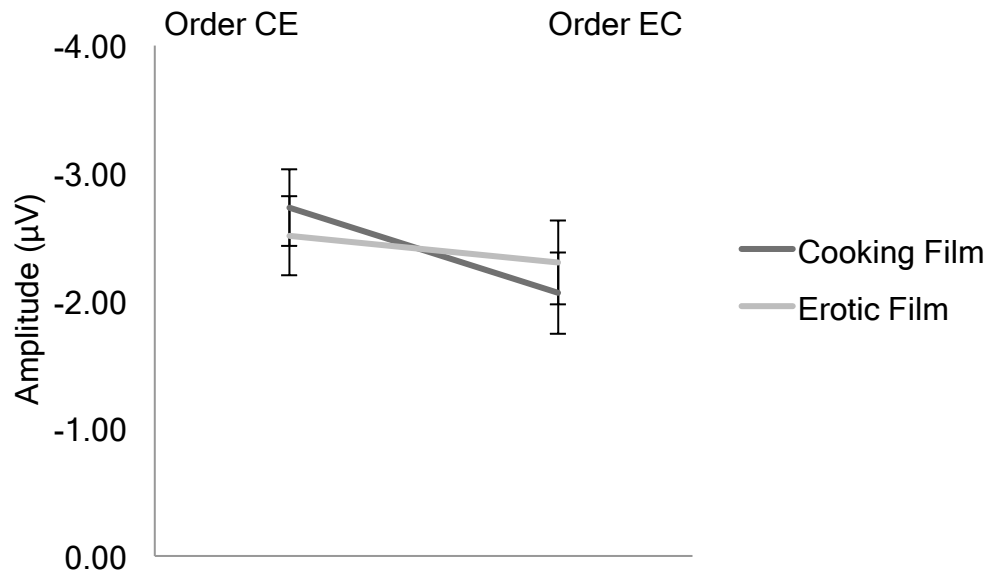
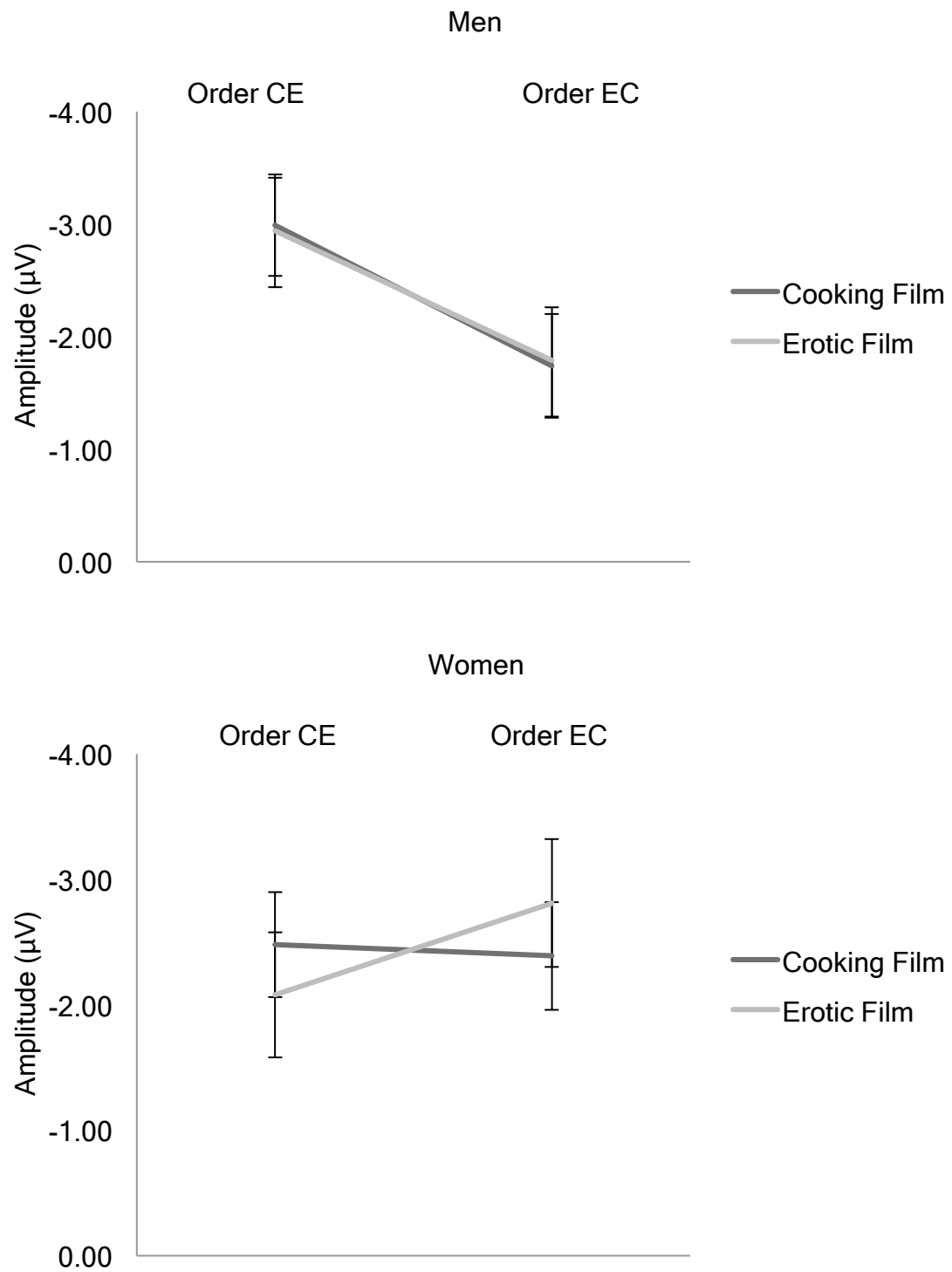


Figure 8. N1 Amplitude as a Function of Film Type and Gender and Order



**Hypothesis #2b.** This hypothesis was tested via a 2 (gender) x 2 (film type [erotic/cooking]) x 2 (order [Order CE/Order EC]) mixed-design ANCOVA (covariate-porn consumption). P3 amplitudes were averaged across the 15 video segments per film, to obtain two averaged P3 amplitude scores for each participant (i.e., an averaged P3 amplitude score for the erotic film and an averaged P3 amplitude score for the cooking film). As the P3 component is positive, larger positive numbers indicate larger amplitudes.

Hypothesis #2b was not confirmed. As reported in Table 6, although there was a significant interaction between film type and gender, it was not the expected pattern of interaction,  $F(1,33) = 4.78, p = .04, \eta_p^2 = .13$  (Figure 9). Simple effects analyses of gender revealed that men evidenced significantly smaller P3 amplitudes towards the cooking film when compared to women,  $p = .03$ .

Table 6

*Mixed-Design Analysis of Covariance of the Auditory P3 Amplitude as a Function of Gender, Film Type, and Order, with Pornography Consumption as a Covariate*

Source	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>	$\eta_p^2$
<i>Between Subjects</i>					
Porn Consumption (CV)	.09	1	.09	.04	.00
Gender	3.16	1	3.16	1.28	.04
Order	3.59	1	3.59	1.46	.04
Gender x Order	3.15	1	3.15	1.28	.04
Error 1	81.40	33	2.47		
<i>Within Subjects</i>					
Film Type	1.22	1	1.22	1.08	.03
Film Type x Porn Consumption (CV)	2.09	1	2.09	1.85	.05
Film Type x Gender	5.41	1	5.41	4.78*	.13
Film Type x Order	1.24	1	1.24	1.10	.03
Film Type x Gender x Order	.91	1	.91	.80	.02
Error 2	37.33	33	1.13		

\* $p < .05$

Figure 9. P3 Amplitude as a Function of Gender and Film Type



**Hypothesis #3a.** *Men's and women's auditory N1 amplitudes will significantly and positively correlate with their score on the subjective sexual arousal question for the erotic film.*

**Hypothesis #3b.** *Men's and women's auditory P3 amplitudes will significantly and negatively correlate with their score on the subjective sexual arousal question for the erotic film.*

A Pearson product-moment correlation was conducted on the averaged subjective sexual arousal score and the averaged N1 and P3 amplitudes collected during the erotic film and during the cooking film. Correlations were calculated separately for men and women, with the intention to perform a Fisher's Z test to investigate if there was a significant difference in correlation strength between men and women.



As reported in Table 7, hypothesis #3a was partially confirmed. There was a significant positive correlation between subjective sexual arousal and the N1 amplitude for men while they viewed the erotic film,  $r(17) = .74, p < .001$  (see Figure 10). For women, the correlation was non-significant,  $r(17) = .07, p = .79$ . Fisher's Z test revealed that the correlation between the N1 and subjective sexual arousal was significantly stronger in men than women,  $Z = 2.49, p = .01$ .

Hypothesis #3b was partially confirmed. There was a significant negative correlation between subjective sexual arousal and the P3 auditory amplitude for women when viewing the erotic film,  $r(17) = -.47, p = .04$  (see Figure 11). For men, the correlation was not significant,  $r(17) = -.12, p = .64$ . Fisher's Z test revealed that there was no significant difference in correlation strength between women and men,  $Z = -1.10, p = .27$ .

Although we did not hypothesize relationships between other subjective emotions and N1 or P3 amplitudes, it seemed pertinent to investigate them. The rationale was that if any other subjective emotion were more strongly correlated with the N1 or P3 amplitudes, it would bring into question if there was a unique relationship with the ERP component and sexual arousal, or if it was simply an indicator of any strong emotional reaction. Also, we felt it was important to investigate the relationship of pornography consumption with subjective emotions and/or ERPs. In the ANOVA's with the entire sample, pornography consumption was included as a covariate because there were significant gender differences in the reported viewing of erotica (with men reporting viewing pornography more often than women). However, as Hypothesis 3 involved separate correlations for men and women, there was no rationale to include pornography

consumption as a covariate in the correlation matrices. Nonetheless, we felt it was important to understand the relationship between consumption. Thus, subjective reports of boredom and disgust while viewing the erotic film and the cooking film and reported pornography consumption were thus added to the correlation matrix. It was decided to leave out subjective excitement as an IV because it was highly correlated with sexual arousal, especially for the erotic film condition,  $r(36) = .92, p < .001$ .

For women, there were a few non-hypothesized correlations between ERP components and self-reported data worth noting: pornography consumption significantly correlated positively with subjective sexual arousal in the erotic film condition,  $r(17) = .78, p < .001$ . Pornography consumption was also significantly and negatively correlated with P3 amplitude in the erotic film condition,  $r(17) = -.53, p = .02$  for women. For men, only one notable non-hypothesized correlation was found; there was a significant correlation between subjective sexual arousal and the N1 auditory amplitude in the cooking film condition,  $r(17) = .47, p = .04$ .

Table 7  
Correlations on Subjective Emotions (Sexual Arousal, Boredom, Disgust) and ERP Components (N1 and P3) During the Erotic Film

	Men		1	2	3	4	5	6	Women	
	Mean	SD							Mean	SD
1. Sexual Arousal	4.04	1.73	1	-0.53*	-0.64**	0.07	-0.47*	0.78***	4.59	1.43
2. Boredom	2.32	1.32	-0.56*	1	0.85***	0.01	0.29	-0.55*	1.80	0.78
3. Disgust	1.28	0.54	-0.11	0.63**	1	0.24	0.16	-0.47*	1.69	0.84
4. N1 Amplitude	-2.16	1.29	0.74***	-0.40 <sup>a</sup>	0.01	1	-0.63*	0.37	-2.56	1.62
5. P3 Amplitude	1.38	1.38	-0.12	-0.01	-0.29	-0.19	1	-0.53*	1.51	1.33
6. Porn Consumption	3.52	1.17	0.04	-0.01	-0.25	0.19	0.30	1	2.26	1.24

\*\* $p < .01$ , \* $p < .05$ , <sup>a</sup> $p < .10$

*Note:* Correlations for men ( $n = 19$ ) are presented below the diagonal, and correlations for women ( $n = 19$ ) are presented above the diagonal. Means and standard deviations for men are located on the left of the correlations, means and standard deviations for the women are located on the right of the correlation.

Figure 10. Men's Correlations of Subjective Sexual Arousal and N1 Amplitudes

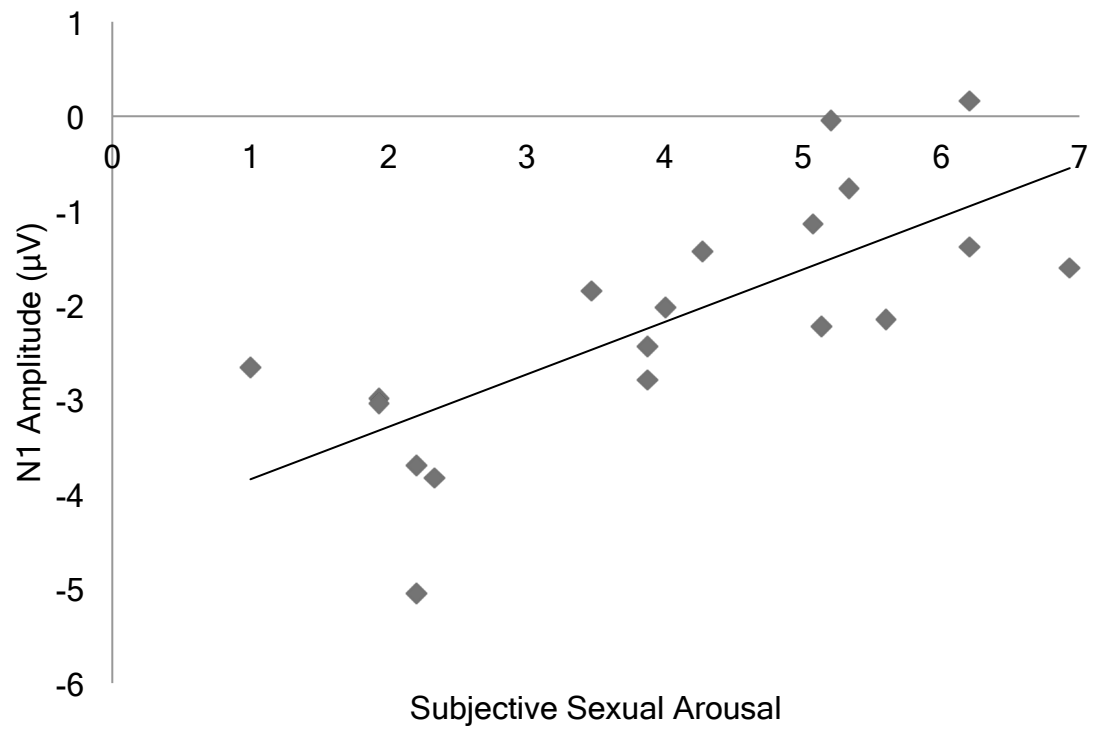
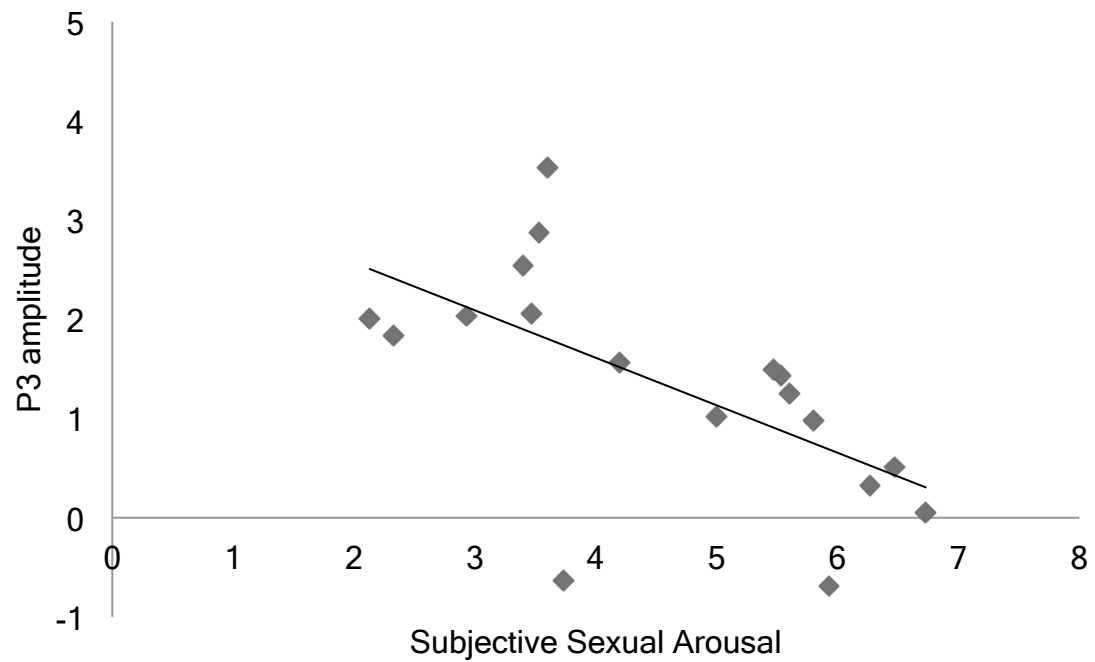


Figure 11. Women's Correlations of Subjective Sexual Arousal and P3 Amplitudes



## CHAPTER 5

### DISCUSSION

#### **Summary of Findings**

The aim of the study was to investigate the concordance rates between Event Related Potentials (ERP) and subjective sexual arousal, with a particular focus on possible gender differences in these concordance rates. As previously presented, research on concordance rates between genital and subjective measures of sexual arousal have consistently shown them to be surprisingly low, especially in women (Chivers et al., 2010). As subjective sexual arousal is a cognitive and emotional event, it was thought that objective indicators in the brain (ERPs) might be more closely aligned to subjective reports of arousal than are indicators of physical arousal (e.g., vasocongestion). However, the hypotheses were largely unsupported.

Our first hypothesis, that there would be a gender by film type interaction on subjective sexual arousal such that men would report significantly more subjective sexual arousal than women while watching the erotic film was not supported. In fact, women reported significantly more sexual arousal than men when viewing the erotic film.

Our second hypothesis was two-part. We hypothesized a gender by film type interaction on (a) the auditory P3 amplitude and on (b) the auditory N1 amplitude such that the amplitudes would be significantly smaller in men as they viewed the erotic film (indicating that the sexual stimuli had more of an interfering effect on the auditory task) than in women. Neither part of the hypothesis was confirmed. For the P3 amplitude, there was a significant interaction between gender and film type, but not in the hypothesized condition. Men evidenced significantly smaller P3 amplitudes to the

cooking film compared to women. For the N1 amplitude, there was no gender by film type interaction; however, we did find a three-way interaction of gender, film type, and order. Simple effect analyses revealed that men evidenced significantly smaller N1 amplitudes when viewing both the erotic and cooking film when the erotic film was presented first.

The third hypothesis was also two-part: we hypothesized that subjective sexual arousal would significantly correlate (a) positively with the auditory N1 amplitude and (b) negatively the auditory P3 ERP amplitude during the erotic film condition in both men and women. This was partially supported for men, and partially supported for women. For men, there was a significant positive correlation between the N1 amplitude and subjective sexual arousal during the erotic film condition. For women, there was a significant negative correlation between the P3 amplitude and subjective sexual arousal during the erotic film condition. Implications of these results are discussed henceforth.

### **Interpretation of the Results**

#### **Unexpected gender differences in the report of subjective sexual arousal.**

Considering that the majority of studies have found that men report more subjective sexual arousal than do women to various sexual stimuli, including films, photographs, and fantasy, it is surprising that we did not find this expected gender difference (Chivers, 2006; Murnen & Stockton, 1997). We even had direct evidence that our specific erotic stimulus (the *Sweet Lady* film) might be more subjectively arousing for men, as one prior research study had found that men reported more sexual arousal to this specific film than did women (Janssen, Carpenter, & Graham, 2002). In fact we found an unexpected

gender difference such that women's rating of subjective sexual arousal was higher than that of men.

Women's higher ratings of subjective sexual arousal may be partially explained by the deception we employed. In an attempt to get as truthful a report of subjective arousal as possible, we told participants that the EEG machine acted as a lie detector. Prior research has found that this approach (called "the bogus pipeline" procedure) leads participants to answer in a more honest way, specifically with reports that are sexual in nature (Roese & Jamieson, 1993). As stated previously, research using the bogus pipeline technique has found that women reported higher rates of masturbation and viewing of erotica when they believed they were hooked up to a non-functional lie detector machine vs. when they were not hooked up (Alexander & Fisher, 2003).

A recently published article on the effects of social desirability on women's reports of sexual arousal did not find this to be true with their sample; continuous reports of sexual arousal were not significantly associated with scores on a social desirability measure in women (Huberman, Suschinsky, Lalumière, & Chivers, 2013). In this two-part study, women were exposed to either audio or film stimuli and asked to rate their sexual arousal. In study one, women were asked to continuously report their sexual arousal towards erotic and neutral audio clips, as well as an overall sexual arousal score after each stimulus presentation. Furthermore, participants responded to a measure that assessed their likelihood of engaging in socially desirable responding, including self-deceptive enhancement (an honest, yet overly-positive response style) and impression management (a deliberate changing of one's answers to create a positive image of oneself). In the second study, women were asked to report their sexual arousal to erotic

and neutral films prior to, continuously throughout, and directly after the films were presented. Again, these women also completed social desirability measures. The authors correlated social desirability scores to sexual arousal reports and found that discrete (but not continuous) measures of sexual arousal were significantly correlated with impression management scores in both studies. Thus, the authors concluded that sex researchers should implement continuous measures of sexual arousal to decrease the influence of socially desirable responding in women. Thus, based on this prior research, it remains puzzling that in our study they reported higher sexual arousal than did men.

Another potential explanation for these results lies in the way in which the erotic film was presented. In order for participants to clearly hear the tones during the viewing of the film, the erotic film audio was muted. Thus, it is possible that this negatively affected men's arousal to a greater extent than women's. Prior research has found that audio accompanying erotic visual stimuli does not significantly increase arousal in women (Lake Polan et al., 2003), while it does in men (Gaither, 1997). Thus, it is possible that the removal of the audio from the erotic film had a more negative impact on men's sexual arousal than on women's.

Yet another potential methodological confound is related to our recruitment strategies. As stated prior, participants were either recruited via the subject-pool for research credits, or via snowball techniques (i.e., asking participants and friends to tell others about the study). Of the 38 participants in our study, 22 were recruited via snowball techniques (13 men and 9 women). It is possible that participants who were recruited into the study via snowball techniques felt less comfortable disclosing information about their arousal as they had some connection to the investigator. As there



were more men who were recruited via snowball techniques, this could have potentially explained why women reported more sexual arousal to the erotic film than men. However, as stated previously, we found no differences in subjective sexual arousal or ERP components based on recruitment type, and we also failed to find a significant recruitment by gender interaction on subjective sexual arousal. It does, however, remain possible that individuals recruited via snowball techniques somehow differed from individuals recruited via the subject-pool in some relevant way that we are not capturing.

Lastly, it is possible that the female investigator who interacted with all of the participants may have impacted reports of sexual arousal. Although frequently the investigator had a research assistant, this person was also a woman in almost all cases. Thus, most of the participants (32 out of 38) interacted with only women prior to and after the viewing of the films. This may have differentially impacted men and women in the study. Research on the effect of interviewer gender on participant responses to sexual topics has yielded some interesting results. Fuchs (2009) conducted a study on the effects of the gender-of-interviewer on 880 participants' responses to sexually related topics. Male participants reported significantly fewer STDs, significantly less instances of frotteurism (defined as rubbing gently on an unsuspecting person in a public place for erotic reasons), and significantly higher reports of virginity when questions were asked by a female interviewer. Female participants reported significantly higher rates of STDs and significantly higher instances of frotteurism when the interviewer was female. In a related study on the effects of the gender of the interviewer on 2,030 participants' responses to sensitive topics (including sexually related topics), both men and women

were significantly more likely to report extra-marital sex to same-sex interviewers than opposite-sex interviewers (Catania, Binson, Canchola, Pollack, & Hauck, 1996).

It is thus possible that men reported less sexual arousal, and/or women reported more sexual arousal in the current study because they were interacting with female researchers. The prior research suggests that individuals are more comfortable disclosing sexually related information to same-sex interviewers, and so the women in our study may have felt more comfortable disclosing their arousal than if there were male investigators present and the men may have felt less comfortable and thus disclosed less. In addition, men have a more obvious indicator of physical arousal than women (i.e., an erection) that could lead to embarrassment in an experimental setting, especially in front of a female investigator. Although all participants were seated in a private room, the EEG equipment was very delicate and required the investigator to re-enter the room at the end of the study to un-hook the equipment from the participant. Every consideration was given to allow the participant time to recover from their possibly aroused state before re-entering into contact with the investigator; the investigator waited until the participant indicated that she could re-enter by a response on the computer screen. Once this indication was given, the investigator would further ask for verbal confirmation that she could re-enter. However, as the participants could not leave the room on their own accord, they may have been anxious that the investigator could enter before they were prepared. Thus, it is possible that men may have actively inhibited their arousal to avoid an erection and any subsequent embarrassment when the investigator re-entered the room.

Although all of the above potential explanations may partially account for the unusual gender differences in subjective arousal in the current study, none appear sufficiently powerful to explain why women's subjective arousal would be significantly higher than men's. Most research studies on sexual arousal share many of the same potential confounds (i.e., men's fear of visible arousal in front of an investigator, using erotic stimuli that may differentially arouse men and women, socially desirable responding, etc.) and yet they have consistently found that men report more subjective arousal to sexual stimuli than do women.

**Auditory N1 amplitudes as an indicator of sexual arousal.** As previously stated, we found no significant gender by film type interaction on N1 amplitudes. Simple effects analyses of a 3-way interaction of film type by gender by order on N1 amplitudes suggested that men evidenced smaller N1 amplitudes to the tone task in both the cooking film condition and the erotic film condition when the erotic film was presented first. For women, tests of simple effects were not significant.

The N1 auditory component seems to reflect various simultaneous cerebral processes. N1 amplitude is influenced by both stimulus-specific and stimulus-nonspecific components (Naatanen & Picton, 1987). Furthermore, the auditory N1 component is generally considered an indicator of memory trace left by previous repetitive stimuli (Lu, Williamson, & Kaufman, 1992a, 1992b; Naatanen & Picton, 1987). This is evidenced by the fact that the N1 auditory component typically decreases, or habituates, if the same auditory or visual stimuli are repeatedly presented (Naatanen & Picton, 1987). Lastly, just as with the P3 component, the N1 component is also related to attention (Parasuraman, 1978).

To the author's knowledge, there is no prior research investigating the role of sexual arousal on the auditory N1 component. However, there is some prior research on the effect of other emotional states on auditory ERPs. For example, Wang and colleagues (2008) were interested in how emotional states may affect processing of auditory tones. They asked participants to view 30 negative, 30 neutral, and 30 positive pictures while being hooked up to an EEG machine. Much as in our study, participants were also asked to listen to auditory tones continuously throughout the viewing of the pictures. Thus, auditory ERPs were collected. Specifically, the researchers were interested in the early latency responses to these tones, and thus looked at an amplitude range that is typically associated with the  $N_a$  component (i.e., a range of 9.4 ms to 22.0 ms after auditory stimulus onset) as opposed to the N1 component, which typically appears 50-200 ms after the stimulus (Naatanen & Picton, 1987). The  $N_a$  amplitude was significantly smaller when participants heard tones while viewing negative vs. neutral stimuli, indicating that negative emotion images captured more attention than neutral images (measured via auditory ERPs). However, there were no significant differences in the  $N_a$  amplitude between positive stimuli vs. neutral or negative stimuli. Thus, based on this study, it seems that negative emotion, as opposed to positive or neutral emotion, affects auditory processing at a very early stage.

Although very little research has been conducted on emotional states and the processing of auditory tones (measured via ERPs), prior research on visual ERPs has yielded some evidence that the N1 component is typically affected by the valence and/or arousal that an image conjures in the participant (for a review, see Olofsson, Nordin, Sequeira, & Polich, 2008). However, comparisons between visual and auditory ERPs are

tentative, at best, as they are not necessarily equivalent. More research is needed to understand the relationship between visual vs. auditory ERP components. Nonetheless, prior research using visual stimuli (and measuring via visual ERPs), have found that the N1 amplitude may be significantly different when participants view emotionally laden pictures (including erotic images) vs. emotionally neutral pictures. In a study by Keil and colleagues (2001), ten participants were asked to view three image types: 20 pleasant pictures (i.e., family and erotic images), 20 unpleasant pictures (i.e., mutilation and attack images), and 20 neutral images (i.e., images of persons and household objects). The authors found that participants' visual N1 amplitude was enhanced when they viewed both pleasant and unpleasant images in comparison to neutral images. This suggests that early processing components (such as the N1) may indicate one's early attention to stimuli with higher arousal properties, at least with visual ERPs (Keil, Müller, Gruber, Wienbruch, Stolarova, & Elbert, 2001). However, in a similar study investigating neural correlates of positive, negative, and neutral picture processing on 11 men, it was found that pleasant pictures (including erotic images) evidenced the most pronounced N1 amplitude enhancement compared to both negative and neutral images (Keil, Bradley, Hauk, Rockstroh, Elbert, & Lang, 2002). Thus, it may be possible, at least in men, that erotic images capture even more attention (measured via N1 amplitudes) than arousing non-erotic images. Again, it remains premature to generalize from visual ERPs to auditory ERPs and only further research will determine whether it is advisable to do so.

In the current study, smaller N1 amplitudes would indicate a greater mental interference in the sensory processing of the tones, possibly because participants are using their sensory processing resources on the film they were watching. It is difficult to

understand why the order in which the films were presented would influence the way in which men processed sensory information; especially when taking into consideration that men evidenced virtually no sensory processing differences (via N1 amplitudes) based on film type.

What is more likely to be the case is that there were pre-existing differences between the participants in Order CE vs. Order EC, a between-subject factor. Although we randomly assigned the order in which participants viewed the films, it is still possible that the pre-existing differences in their neuronal processing resulted in N1 amplitude differences between men who were in Order EC vs. Order CE. Based on these results, it would suggest that men in the Order CE condition had larger baseline N1 amplitudes than the men in the Order EC condition, regardless of the order in which they watched the films.

**Auditory P3 amplitudes as an indicator of sexual arousal.** The fact that men evidenced significantly smaller P3 amplitudes than women during the cooking film condition was hardly the type of film by gender interaction we expected.

The P3 component is an attention-driven process that taps into working memory and context updating (Heslenfeld, 2003; Kujala & Naatanen, 2003). In our study, we would have expected men and women to have less mental capacity to process the tones when concentrating on the sexual stimuli. This would have materialized as smaller P3 amplitudes to the tones presented during the erotic film condition vs. the tones presented in the cooking film condition. And, because we expected men to report more subjective arousal, we expected P3 amplitudes to be even smaller for men during the erotic film than for women.

Prior research has found participants usually require more mental recourses to process erotic stimuli (both measured via auditory and visual ERPs), especially in relation to the P3 component (Krug et al., 2000; Steele et al., 2013; van Lankveld & Smulders, 2009; Vardi et al., 2006). In fact, our study was adapted from the research study conducted by Vardi and colleagues (2006), in which they examined P3 auditory amplitudes to assess sexual arousal and/or sexual interest to an erotic film. When the authors exposed 30 men and women to film clips of sports, scenery, and sex, participants evidenced the largest decrease in the P3 auditory amplitudes when presented with target tones during the erotic clip condition compared to the sports or scenery film clips ( $p < .001$ ). However, in order to account for individual differences, Vardi and colleagues used baseline measures of P3 amplitudes that were then subtracted from P3 amplitudes when participants viewed the films. Perhaps our decision to not use difference scores from baseline explains our lack of similar results. We decided against implementing this methodological strategy because we were worried about excessively boring participants when collecting baseline measures of ERPs in an already time-consuming study.

In a more recent study assessing sexual desire via visual ERPs to sexual images, again it was found that participants' P3 amplitudes significantly differed based on the erotic content of stimuli. Fifty-two participants who reported problems regulating their viewing of visual pornography were asked to view emotional/sexual stimuli (i.e. pleasant sexual, pleasant non-sexual, neutral, and unpleasant) while hooked up to an EEG machine. The P3 amplitude was the largest when participants viewed the pleasant sexual stimuli ( $p < .001$ ) (Steele, Staley, Fong, & Prause, 2013). As they were measuring visual ERPs and did not use auditory tones to distract participants from their visual stimuli,

larger P3 amplitudes would indicate more visual attention paid towards erotic images compared to non-erotic images.

In our study, significant differences between men and women were, strangely, found in the cooking film condition. Could men have been attending more to the cooking film than women and thus had less attentional and mental resources (measured via P3 amplitude) for processing the target tones? If we found that men evidenced smaller amplitudes than women in the erotic film condition, we would have concluded it was likely due to men feeling more sexually aroused. But, in this case, it seems highly unlikely that men's P3 amplitudes were significantly smaller than women's because the men were more sexually aroused to the cooking film than women. As reported in Table 2, men's reports of sexual arousal during the cooking film condition were very low ( $M = 1.03$  on a 1-7 scale). Furthermore, we did not find men's P3 amplitudes to be significantly correlated with subjective sexual arousal while they were watching the cooking film. Thus, the men could have been attending to the cooking film for other, non-sexual reasons.

It is also possible that the men in this study were so bored by the cooking film that they disengaged from the study almost entirely. Possibly, their attention was turned inward to such an extent that they had less mental resources to attend to the tones. Men rated their boredom to the cooking film as high ( $M = 4.71$  on a 1-7 scale). They may have been so bored that they found it hard to attend to any aspect of the study at that time, including both the cooking film and the tones. Thus, when the erotic film was playing, they were actually more engaged in the study, and had more mental resources to attend to both the film and the tones. This could, at least in part, explain why men's P3 amplitudes



were significantly smaller in the cooking film condition than the erotic film condition. Related to self-reports of boredom during film viewing, we also collected data on participants' reports of the percentage of time they felt they were paying attention to the erotic film and the cooking film. Results showed that men and women did not differ significantly in self-reported attention to either the cooking film or the erotic film. Thus, at least based on their self-reported measure of attention, it does not seem to be that men in our study were any more disengaged from the cooking film than were women.

**Gender differences in correlations between subjective sexual arousal and auditory ERP components.** Interestingly, we found that two different ERP components correlated with subjective sexual arousal for men and women. Some prior research has concentrated on cerebral areas in the brain that evidence activation when participants report sexual arousal (Léon-Carrión, et al., 2007a, 2007b; Stoléru et al., 1999), but few studies have investigated auditory ERP components in relation to the experience of sexual arousal. In fact, to the author's knowledge, this is the first study that has investigated the concordance rate between auditory N1 amplitude and subjective sexual arousal in men and women. Below is a discussion of these significant correlations.

***Positive correlation between the N1 component and subjective sexual arousal in men.*** As the correlation between N1 amplitudes and subjective sexual arousal was significant in men, the smaller N1 amplitudes may indicate that these men had less attentional resources available to process the sensory information of the auditory tones as they were becoming sexually aroused to the erotic film. Again, as the N1 is a negative component, smaller amplitudes would equate to less negative numbers, which would lead to a hypothesized positive correlation between N1 amplitudes and reports of sexual

arousal. As previously stated, research has shown that the N1 amplitude is related to attention and sensory processing (Näätänen & Picton, 1987; Olofsson et al., 2008). The N1 component typically occurs between 50 and 150 ms after the stimulus is presented, possibly indicating that the processing of sexual arousal in men is happening at a very early stage.

Although this may be the first research study to investigate the auditory N1 component and its relationship to subjective sexual arousal in men and women, some studies have investigated the visual N1 component in relation to other emotional states (Olofsson et al., 2008). As afore-mentioned, some research has found that the N1 component is enhanced with positive and/or negative valance images (Keil et al., 2001; Keil et al., 2002), suggesting that the visual N1 component is related to the emotional processing of images. Something similar may be happening for the processing of auditory tones while viewing erotic stimuli, specifically for men. In fact, prior research on men's neuronal attention to emotionally positive (and erotic) and negative vs. neutral stimuli, has found erotic images to capture even more attention (measured via visual N1 amplitudes) than arousing non-erotic images (Keil et al., 2002). Thus, maybe the auditory N1 component is more closely aligned to subjective sexual arousal in men vs. women. In the current study, it seems that men's subjective sexual arousal is interfering with their ability to process sensory components of auditory stimuli. This may suggest that men's sexual arousal is tied to early sensory processing levels, at least when using a visual erotic film to induce sexual arousal and auditory tones to gather ERP information.

***The P3 component is negatively correlated with subjective sexual arousal in women.*** For women, we found a significant negative correlation between P3 amplitudes

and subjective sexual arousal during the erotic film condition. This finding supported our hypothesis. Not only is the auditory P3 component an indicator of attention, it only appears when a stimulus change is detected (i.e., when a frequency change in the “target” tone is presented after multiple “standard” tones of the same frequency were presented), and thus it seems to be related to memory processing (Polich, 2007). Furthermore, the P3 amplitude is an indicator of a participant’s effort and mental resources on any given task (Luck, 2005). Thus, in this study, as female participants were using their mental resources to attend to the erotic film, their mental capacity may have been overloaded when they were asked to process the tones (Vardi, et al., 2006). For women, it appears that subjective sexual arousal may be related to attention and memory processing. Prior research has found the P3 (both measured via auditory and visual ERPs) to be significantly correlated with subjective sexual arousal in men and women (Stele et al., 2013; van Lankveld & Smulders, 2009; Vardi et al., 2006). However, in our study, we found that P3 amplitudes were significantly related to subjective sexual arousal in women only.

***Comparing concordance rates between subjective sexual arousal and differing measures of physical/objective sexual arousal.*** A majority of the prior research studies on concordance rates of subjective and physical sexual arousal has investigated correlations between reports of subjective arousal and genital vasocongestion (measured via genital plethysmography). As previously stated, concordance rates between subjective sexual arousal and genital plethysmography have been moderate in men ( $r = .66$ ), and perplexingly low in women ( $r = .26$ ) (Chivers et al., 2010). While both men and women tend to report sexual arousal to their preferred sexual target (i.e., heterosexual

men reporting higher rates of sexual arousal to erotic stimuli with women present, heterosexual women reporting higher rates of sexual arousal to erotic stimuli with men present), it seems that women typically evidence non-category specific genital arousal to any intense sexual stimulus (Chivers et al., 2010). Furthermore, this same pattern of non-category specificity has been evidenced in women's viewing pattern to erotic stimuli as well (Lykins et al., 2008; Rupp & Wallen, 2007). We reasoned that there might be an objective measure of sexual arousal that could more strongly correlate with women's subjective arousal if we investigated brain activation. After all, the experience of sexual arousal is a mental and emotional event, and thus, it would seem that an objective measure in the brain might more closely align with the experience of sexual arousal, especially for women.

Based on our findings, it seems that certain types of brain activity (measured via auditory ERPs) may be more closely aligned than genital vasocongestion with both men's and women's subjective sexual arousal. However, gender differences emerged in regards to the type of ERP component that was related to participants' subjective sexual arousal. For men, there was a significant positive correlation between N1 and subjective sexual arousal, while it was not significant in women ( $r = .74$  vs.  $r = .07$ ). For women, there was a significant negative correlation between P3 and subjective sexual arousal, while it was not significant in men ( $r = -.47$  vs.  $r = -.12$ ).

One of the nagging confounds of the concordance rates between subjective sexual arousal and genital vasocongestion is that it necessitates different instruments for men and women. Using ERPs as an objective measure of sexual arousal, we were able to use the same instrument for both men and women. However, gender differences still

emerged in regards to which ERP component related to subjective sexual arousal. These results suggest that it is possible that subjective sexual arousal is related to slightly different mental processing between men and women. Is it possible that sexual arousal is experienced differently by men and women? After all, gender differences are found in genital arousal, eye tracking of erotic images, and now we find it in brain activity measured via auditory ERPs.

Another noteworthy finding relates to the marked gender differences in the strength of concordance rates between ERPs and subjective sexual arousal. Men's concordance rate between the N1 component and subjective sexual arousal was significantly higher than women's; and although women's concordance rate between P3/subjective sexual arousal was higher than men's, it was not significantly so (as per Fisher's Z). Thus, it seems that our objective measure of sexual arousal is more closely aligning to men's subjective sexual arousal than to women's. This leaves us to wonder if there is any reliable objective measure that can more fully capture women's subjective experience of arousal. Based on our findings, although certain ERP components seem to be more reliable predictors of subjective sexual arousal in both men and women than genital vasocongestion, the gender difference in the strength of concordance rates is still present. Caution should be used in interpreting these results, however, as more research is needed in order to fully understand whether there truly are gender differences in how ERPs relate to subjective sexual arousal in men and women.

**Non-hypothesized findings worth noting.** Although not hypothesized, there were some interesting results that emerged from ANCOVA and correlation analyses. Below, we discuss these results and offer some interpretations.

*The effect of pornography consumption on sexual arousal and P3 amplitude in women.* When testing Hypothesis 3 [that men's and women's subjective sexual arousal scores will (a) positively correlate with N1 amplitudes, and (b) negatively correlate with P3 amplitudes], we decided to include pornography consumption in the correlation matrix in order to gain understanding of the relationship between sexual arousal and pornography consumption in men and women. For women, there were two significant correlations worth noting: there was a significant positive correlation between pornography consumption and subjective sexual arousal during the erotic film condition, and a significant negative correlation between pornography consumption and P3 amplitude during the erotic film condition. Thus, pornography consumption was a predictor of both subjective sexual arousal and P3 amplitude in women when viewing the erotic film.

Although one could have reasonably posited that higher pornography consumption could have resulted in lower subjective arousal to the erotic clip due to habituation or desensitization, that did not seem to be the case with the women in our sample. Alternately, women who view more pornography may be more interested in sex and have a higher arousability. There is some evidence that women who view pornography masturbate more often (Baćak & Štulhofer, 2011). Write and colleagues (2013) conducted a large national study (18,225 women residing in the US) investigating predictors and correlates of women's pornography consumption. Women who consumed pornography reported more sex partners, had more positive attitudes towards extramarital, premarital, and teenage sex, and were more likely in the last five years to have engaged in extramarital and/or premarital sex. Our findings add to this research by

suggesting that women who consume more pornography may also report greater sexual arousal and evidence greater brain activity (specifically via P3 auditory ERP amplitudes) toward erotic films than non-consumers. Of course, more research should be conducted to substantiate this claim.

***The effect of film presentation order in subjective sexual arousal and P3/N1 amplitudes.*** When participants were watched the cooking film first, they reported less subjective arousal to the erotic film than when they viewed the erotic film first. We suspect this was due to the fact that participants were asked to sit as still as possible for the entire duration of the films in order to get clear readings of brain activity. Thus, participants may have been more physically and mentally fatigued by the time that the erotic film was presented when it was presented after the cooking film. This could have had a negative effect on their subjective sexual arousal.

We also found that the N1 amplitude was significantly correlated with reports of sexual arousal during the cooking film in men. We suspect that these men were not actually arousing to the cooking film but rather that this was a byproduct of the order in which the films were presented. We did not have a distractor task between the two films, and thus some men may have still been aroused once they started watching the cooking film when it was presented after the erotic film. This would have resulted in higher scores of arousal and smaller N1 amplitudes at the beginning of the cooking film for the men who viewed the erotic film first. However, as the cooking film progressed, it is likely that these men returned to their un-aroused state, which would have resulted in a decrease in reports of sexual arousal and an increase in N1 amplitude (or a larger

negative N1 amplitude). If this were the case, this would appear as a significant positive correlation between N1 amplitude and subjective sexual arousal during the cooking film.

### **Limitations**

One obvious limitation in this research study is the lack of a distractor task between the two conditions. A distractor task was decided against in order to save time. However, it became obvious that without a distractor task, the order in which the films were presented became an issue. When participants viewed the erotic film first, their arousal may have been present when the cooking film began. This is likely why there were so many effects of order in our results. It is impossible to know for sure if a distractor task would have resulted in no order effects, but the fact that we had order effects necessitated the addition of order as an additional between-subjects factor into the ANCOVAs, which decreased our power to detect effects. This was especially problematic when investigating simple effects in significant interactions, as sample size became an issue with these comparisons, despite the fact that our sample size of 38 (19 men and 19 women) is relatively large for ERP studies. Thus, not having a distractor task may have caused more complications than previously believed. In future similar studies, a distractor task is recommended.

Another potential limitation is the use of auditory ERPs instead of visual ERPs to measure attention and/or arousal. Although we adapted our methodology from a similar research study by Vardi and colleagues (2006), it is possible that auditory ERP's are not optimal to capture sexual arousal. Some recent studies have shown promising results using visual ERPs (specifically analyzing the P3 component) to assess sexual arousal (Steele et al., 2013; Briggs & Martin, 2009). It may be possible that visual ERPs are



more closely aligned to an individual's subjective sexual arousal than auditory ERPs. As illustrated prior, many studies using visual ERPs have found significant differences in the processing of erotic vs. non-erotic stimuli (Krug et al., 2000; Steele, Staley et al., 2013; van Lankveld & Smulders, 2009), or positive stimuli (containing erotic images) vs. negative and/or neutral stimuli (Keil et al., 2001; 2002). However, to the author's knowledge, only two studies have implemented auditory ERPs to investigate the processing of erotic vs. non-erotic stimuli (Vardi et al., 2006; Vardi et al., 2009). Furthermore, using auditory ERPs in the way we did was an indirect measure of attention to our erotic stimuli. In this auditory ERP study, the tones were acting as a distractor to the highly relevant erotic film, and thus, our ERP data was measuring the amount to which the tones distracted the participants from the erotic and cooking films. Visual ERPs were not advisable to use in the current study, as it is difficult to time-lock visual ERPs to a complex visual task, such as a film. So, to use visual ERPs in the current study, still images would have been substituted as the erotic stimuli in lieu of the erotic and cooking films. We decided against this as felt that erotic still images would likely be less sexually arousing when compared to the dynamic erotic film. However, if visual ERPs were used to assess the mental processing of (different) visual erotic stimuli, it would have been a more direct measure; because unlike the auditory ERPs, the visual ERPs would have been directly connected to the mental processing of the visual erotic stimuli. Thus, using visual ERPs in future research may possibly be a more accurate measure of the neuronal processing of sexual arousal to visual erotic stimuli than auditory ERPs to a distractor task.

Another limitation, and perhaps the most impactful, is the lack of a baseline ERP measure to later subtract from participants' ERPs during their viewing of the films. Most ERP studies use within-subject designs to account for individual differences in neuronal processing of auditory or visual stimuli. As we were comparing men and women in our study, we could not have a purely within-subjects design. Because gender is a between-subjects factor, we collected a larger number of participants than the typical ERP study (with 19 men and 19 women in this specific study). However, if we had collected baseline measures, it may have decreased some of the individual differences between participants' "typical" auditory ERPs to any stimuli. We decided against baseline measures because we were worried about adding excessive time to the research study. This baseline condition would have consisted of an overly simple task in which participants identified target tones from standard tones without any accompanying visual stimuli. In order to get an equal number of ERPs for analyses, participants would have been asked to identify tones for 15 minutes, the same amount of time each of the films were presented. As our study was already 90 minutes in length including set-up and debriefing time, we were concerned that participants would be fatigued and/or overly bored when the viewing of the films finally occurred. However, in hindsight, it may have been wiser for us to add a baseline condition to our study to control for individual differences in ERP amplitudes.

Another potential problem was our choice of a non-sexual film. Based on the results presented in this study, our cooking film seemed to have been a sub-optimal control film as we found gender differences in the mental processing of this film. Some prior research included multiple non-sexual stimuli, including sports content and scenery

content (Vardi et al., 2006), skydiving, portraits, mutilated images of bodies (Steele et al., 2013), and babies and adults in non-sexual activities (Johnston & Wang, 1991). Again, for time constraint reasons, we decided to only have one control film instead of multiple ones. The reason we chose to use a cooking film as our control was that we wanted to find a non-sexual act for a man and woman to engage in. Prior research has found that ERP amplitudes are more pronounced when viewing human faces (Botzel & Grusser, 1989; Carretie & Iglesias, 1995; Jeffreys, 1989), and thus, we wanted our control film to also have a man and a woman in a majority of scenes to control for ERP amplitude differences that may appear just from viewing human faces. However, based on our research, it seems that men and women mentally processed the cooking film differently, and therefore it was not a good control film for our study. Thus, it would have been beneficial to pilot the cooking film prior to using it in this study, and/or possibly include more than one non-sexual film as a “control” film. In addition to including multiple “control” films, it also may have been beneficial to include multiple erotic films, as well as other means of inducing sexual arousal (i.e., imagination of erotic events, auditory erotic stimuli, etc.). Another study paradigm that may have helped elucidate the complexity of sexual arousal is if we included multiple erotic films with increasing explicitness. For example, starting with a less explicit and possibly less arousing stimulus (i.e. a film of nude men and women in non-sexual acts), a moderately explicit and/or arousing stimulus (i.e. an erotic film of nude men and women engaging in heavy petting), to a highly explicit and/or arousal stimulus (i.e. an erotic film of a man and a woman engaging in oral and penetrative sex). Having limited our sexual arousal condition to one erotic film leaves open the possibility that our film was just not

sufficiently arousing. Lastly, it should be noted that we did not have control conditions for type of arousal. By not showing films that produce other types of arousal (e.g., fear) we cannot be certain that the auditory N1 and P3 ERP amplitudes were exclusive to sexual arousal. These amplitudes may have been produced by any type of arousal.

### **Future Directions**

In light of the study's limitations, future studies could address these problems while building on the current literature on sexual arousal and ERPs. Thus, different methodology (specifically, adding a distractor task in between films, piloting the films prior to use, using multiple films per condition, controlling for types of arousal, and collecting baseline ERP data) may yield different results. More research should be conducted to investigate whether concordance rates between ERP components and subjective sexual arousal are stronger than what is found when correlating genital vasocongestion with subjective sexual arousal in both men and women. Based on our research, there is some evidence that some ERP components may be more closely aligned with subjective reports of sexual arousal than genital vasocongestion, although intriguing gender differences were found in this study. Moreover, a replication study would also further clarify whether there truly are gender differences in concordances between N1 amplitudes and subjective sexual arousal and P3 amplitudes and subjective sexual arousal. To the author's knowledge, this is the first study that has found a gender difference in the neuronal processing of subjective sexual arousal (measured via auditory ERPs). Thus, future research studies interested in investigating concordance rates between ERP components and subjective sexual arousal should be conducted to see if this result could be replicated.

Future studies may also want to investigate whether men's and women's processing (measured via ERPs) of various erotic stimuli evidences some of the gender differences that are found in genital vasocongestion to preferred and non-preferred sexual stimuli (for review, see Chivers, 2007). It may be informative to replicate the study by Chivers and Bailey (2005) using EEG data to investigate whether gender differences arise in ERPs when participants view preferred and non-preferred visual sexual stimuli. Overall, more research is needed on the use of ERPs to establish it as a possible indicator of sexual arousal in men and women.

## APPENDIX I: DEMOGRAPHIC QUESTIONNAIRE

1. How old are you (in years)? \_\_\_\_\_

2. Gender:

- ☐ Man
- ☐ Woman
- ☐ Other (please explain) \_\_\_\_\_

3. Sexual Orientation:

- ☐ Heterosexual (straight)
- ☐ Homosexual (gay/lesbian)
- ☐ Bisexual
- ☐ Other (please explain) \_\_\_\_\_

4. Which of the following ethnic groups do you most identify with?

- ☐ Caucasian (European- American)
- ☐ African American/Black
- ☐ Hispanic/Latino
- ☐ Asian
- ☐ Native American
- ☐ Other (please explain) \_\_\_\_\_

5. What is your current religion?

- ☐ Christian
- ☐ Catholic
- ☐ Mormon
- ☐ Jewish
- ☐ Muslim
- ☐ Hindu
- ☐ Buddhist
- ☐ No religion
- ☐ Other (please explain) \_\_\_\_\_

6. What is the highest level of education you have completed?

- ☐ Elementary School
- ☐ High school Diploma/ GED
- ☐ Some College
- ☐ College Degree
- ☐ Graduate or Professional Degree
- ☐ Other (please explain) \_\_\_\_\_

7. What is your household income?

- ☐ Under \$20,000
- ☐ \$20,000-\$29,999
- ☐ \$30,000-\$39,000
- ☐ \$40,000-\$49,000
- ☐ \$50,000-\$59,000
- ☐ \$60,000-\$69,000
- ☐ \$70,000-\$79,000
- ☐ \$80,000-\$89,000
- ☐ \$90,000-\$99,000
- ☐ \$100,000-\$149,000
- ☐ \$150,000-\$200,000
- ☐ Over \$200,000

8. Current relationship status:

- ☐ Single and NOT dating
- ☐ Single and dating
- ☐ Have a steady partner
- ☐ Cohabiting or married
- ☐ Widowed
- ☐ Divorced
- ☐ Other (please explain)\_\_\_\_\_

9. Have you ever had sex in your lifetime?

- ☐ Yes
- ☐ No
- ☐ Other (please explain)\_\_\_\_\_

10. How often do you watch pornography/erotica?

- ☐ Never
- ☐ Rarely- viewed less than 10 times ever
- ☐ Rarely- viewed less than once a month
- ☐ Regularly- viewed monthly
- ☐ Regularly- viewed weekly
- ☐ Regularly- viewed daily
- ☐ Other (please explain)\_\_\_\_\_

## APPENDIX II: KINSEY HETEROSEXUAL-HOMOSEXUAL SCALE

What is your sexual orientation? (Please circle one)

- 0 Exclusively heterosexual
- 1 Predominately heterosexual, only incidentally homosexual
- 2 Predominately heterosexual, but more than incidentally homosexual
- 3 Equally heterosexual and homosexual
- 4 Predominately homosexual, but more than incidentally heterosexual
- 5 Predominately homosexual, only incidentally heterosexual
- 6 Exclusively homosexual



### APPENDIX III: SUBJECTIVE SEXUAL AROUSAL QUESTIONS

**Please click on the number that best describes your emotions at this time. To what extent did the film (images) elicit the following emotions in you?**

**Excitement**

1	2	3	4	5	6	7
Not at all						Extremely

**Sexual Arousal**

1	2	3	4	5	6	7
Not at all						Extremely

**Boredom**

1	2	3	4	5	6	7
Not at all						Extremely

**Disgust**

1	2	3	4	5	6	7
Not at all						Extremely

## APPENDIX IV: THE FEMALE SEXUAL FUNCTION INDEX

### Female Sexual Function Index (FSFI)

Subject Identifier \_\_\_\_\_ Date \_\_\_\_\_

**INSTRUCTIONS:** These questions ask about your sexual feelings and responses during the past 4 weeks. Please answer the following questions as honestly and clearly as possible. Your responses will be kept completely confidential. In answering these questions the following definitions apply:

Sexual activity can include caressing, foreplay, masturbation and vaginal intercourse.

Sexual intercourse is defined as penile penetration (entry) of the vagina.

Sexual stimulation includes situations like foreplay with a partner, self-stimulation (masturbation), or sexual fantasy.

### **CHECK ONLY ONE BOX PER QUESTION.**

Sexual desire or interest is a feeling that includes wanting to have a sexual experience, feeling receptive to a partner's sexual initiation, and thinking or fantasizing about having sex.

1. Over the past 4 weeks, how often did you feel sexual desire or interest?

- ☐ Almost always or always
- ☐ Most times (more than half the time)
- ☐ Sometimes (about half the time)
- ☐ A few times (less than half the time)
- ☐ Almost never or never

2. Over the past 4 weeks, how would you rate your level (degree) of sexual desire or interest?

- ☐ Very high
- ☐ High
- ☐ Moderate
- ☐ Low
- ☐ Very low or none at all

Sexual arousal is a feeling that includes both physical and mental aspects of sexual excitement. It may include feelings of warmth or tingling in the genitals, lubrication (wetness), or muscle contractions.

3. Over the past 4 weeks, how often did you feel sexually aroused ("turned on") during sexual activity or intercourse?

- ☐ No sexual activity
- ☐ Almost always or always
- ☐ Most times (more than half the time)
- ☐ Sometimes (about half the time)
- ☐ A few times (less than half the time)
- ☐ Almost never or never

4. Over the past 4 weeks, how would you rate your level of sexual arousal ("turn on") during sexual activity or intercourse?

- ☐ No sexual activity
- ☐ Very high
- ☐ High
- ☐ Moderate
- ☐ Low
- ☐ Very low or none at all

5. Over the past 4 weeks, how confident were you about becoming sexually aroused during sexual activity or intercourse?

- ☐ No sexual activity
- ☐ Very high confidence
- ☐ High confidence
- ☐ Moderate confidence
- ☐ Low confidence
- ☐ Very low or no confidence

6. Over the past 4 weeks, how often have you been satisfied with your arousal (excitement) during sexual activity or intercourse?

- ☐ No sexual activity
- ☐ Almost always or always
- ☐ Most times (more than half the time)
- ☐ Sometimes (about half the time)
- ☐ A few times (less than half the time)
- ☐ Almost never or never

7. Over the past 4 weeks, how often did you become lubricated ("wet") during sexual activity or intercourse?

- ☐ No sexual activity
- ☐ Almost always or always
- ☐ Most times (more than half the time)
- ☐ Sometimes (about half the time)
- ☐ A few times (less than half the time)
- ☐ Almost never or never

8. Over the past 4 weeks, how difficult was it to become lubricated ("wet") during sexual activity or intercourse?

- ☐ No sexual activity
- ☐ Extremely difficult or impossible
- ☐ Very difficult
- ☐ Difficult
- ☐ Slightly difficult
- ☐ Not difficult

9. Over the past 4 weeks, how often did you maintain your lubrication ("wetness") until completion of sexual activity or intercourse?

- ☐ No sexual activity
- ☐ Almost always or always
- ☐ Most times (more than half the time)
- ☐ Sometimes (about half the time)
- ☐ A few times (less than half the time)
- ☐ Almost never or never

10. Over the past 4 weeks, how difficult was it to maintain your lubrication ("wetness") until completion of sexual activity or intercourse?

- ☐ No sexual activity
- ☐ Extremely difficult or impossible
- ☐ Very difficult
- ☐ Difficult
- ☐ Slightly difficult
- ☐ Not difficult

11. Over the past 4 weeks, when you had sexual stimulation or intercourse, how often did you reach orgasm (climax)?

- ☐ No sexual activity
- ☐ Almost always or always
- ☐ Most times (more than half the time)
- ☐ Sometimes (about half the time)
- ☐ A few times (less than half the time)
- ☐ Almost never or never

12. Over the past 4 weeks, when you had sexual stimulation or intercourse, how difficult was it for you to reach orgasm (climax)?

- ☐ No sexual activity
- ☐ Extremely difficult or impossible
- ☐ Very difficult
- ☐ Difficult
- ☐ Slightly difficult
- ☐ Not difficult

13. Over the past 4 weeks, how satisfied were you with your ability to reach orgasm (climax) during sexual activity or intercourse?

- ☐ No sexual activity
- ☐ Very satisfied
- ☐ Moderately satisfied
- ☐ About equally satisfied and dissatisfied
- ☐ Moderately dissatisfied
- ☐ Very dissatisfied

14. Over the past 4 weeks, how satisfied have you been with the amount of emotional closeness during sexual activity between you and your partner?

- ☐ No sexual activity
- ☐ Very satisfied
- ☐ Moderately satisfied
- ☐ About equally satisfied and dissatisfied
- ☐ Moderately dissatisfied
- ☐ Very dissatisfied

15. Over the past 4 weeks, how satisfied have you been with your sexual relationship with your partner?

- ☐ Do not currently have a partner
- ☐ Very satisfied
- ☐ Moderately satisfied
- ☐ About equally satisfied and dissatisfied
- ☐ Moderately dissatisfied
- ☐ Very dissatisfied

16. Over the past 4 weeks, how satisfied have you been with your overall sexual life?

- ☐ Very satisfied
- ☐ Moderately satisfied
- ☐ About equally satisfied and dissatisfied
- ☐ Moderately dissatisfied
- ☐ Very dissatisfied

17. Over the past 4 weeks, how often did you experience discomfort or pain during vaginal penetration?

- ☐ Did not attempt intercourse
- ☐ Almost always or always
- ☐ Most times (more than half the time)
- ☐ Sometimes (about half the time)
- ☐ A few times (less than half the time)
- ☐ Almost never or never

18. Over the past 4 weeks, how often did you experience discomfort or pain following vaginal penetration?

- ☐ Did not attempt intercourse
- ☐ Almost always or always
- ☐ Most times (more than half the time)
- ☐ Sometimes (about half the time)
- ☐ A few times (less than half the time)
- ☐ Almost never or never

19. Over the past 4 weeks, how would you rate your level (degree) of discomfort or pain during or following vaginal penetration?

- ☐ Did not attempt intercourse
- ☐ Very high
- ☐ High
- ☐ Moderate
- ☐ Low
- ☐ Very low or none at all

***Thank you for completing this questionnaire***

## APPENDIX V: INTERNATIONAL INDEX OF ERECTILE DYSFUNCTION

Instructions: These questions ask about the effects your erection problems have had on your sex life, over the past 4 weeks. Please answer the following questions as honestly and clearly as possible. In answering these questions, the following definitions apply:

*Definitions:*

*Sexual activity includes intercourse, caressing, foreplay and masturbation*

*Sexual intercourse is defined as vaginal penetration of the partner (you entered the partner)*

*Sexual stimulation includes situations like foreplay with a partner, looking at erotic pictures, etc.*

*Ejaculate is defined as the ejection of semen from the penis (or the feeling of this)*

**Mark ONLY one circle per question:**

1. Over the past 4 weeks, how often were you able to get an erection during sexual activity?

- ☐ No sexual activity
- ☐ Almost always or always
- ☐ Most times (much more than half the time)
- ☐ Sometimes (about half the time)
- ☐ A few times (much less than half the time)
- ☐ Almost never or never

2. Over the past 4 weeks, when you had erections with sexual stimulation, how often were your erections hard enough for penetration?

- ☐ No sexual stimulation
- ☐ Almost always or always
- ☐ Most times (much more than half the time)
- ☐ Sometimes (about half the time)
- ☐ A few times (much less than half the time)
- ☐ Almost never or never

Questions 3, 4 and 5 will ask about **erections** you may have had during sexual intercourse.

3. Over the past 4 weeks, when you attempted sexual intercourse, how often were you able to penetrate (enter) your partner?

- ☐ Did not attempt intercourse
- ☐ Almost always or always

- ☐ Most times (much more than half the time)
- ☐ Sometimes (about half the time)
- ☐ A few times (much less than half the time)
- ☐ Almost never or never

4. Over the past 4 weeks, during sexual intercourse, how often were you able to maintain your erection after you had penetrated (entered) your partner?

- ☐ Did not attempt intercourse
- ☐ Almost always or always
- ☐ Most times (much more than half the time)
- ☐ Sometimes (about half the time)
- ☐ A few times (much less than half the time)
- ☐ Almost never or never

5. Over the past 4 weeks, during sexual intercourse, how difficult was it to maintain your erection to completion of intercourse?

- ☐ Did not attempt intercourse
- ☐ Almost always or always
- ☐ Most times (much more than half the time)
- ☐ Sometimes (about half the time)
- ☐ A few times (much less than half the time)
- ☐ Almost never or never

6. Over the past 4 weeks, how many times have you attempted sexual intercourse?

- ☐ No attempts
- ☐ 1-2 attempts
- ☐ 3-4 attempts
- ☐ 5-6 attempts
- ☐ 7-10 attempts
- ☐ 11 or more attempts

7. Over the past 4 weeks, when you attempted sexual intercourse how often was it satisfactory for you?

- ☐ Did not attempt intercourse
- ☐ Almost always or always
- ☐ Most times (much more than half the time)
- ☐ Sometimes (about half the time)
- ☐ A few times (much less than half the time)
- ☐ Almost never or never

8. Over the past 4 weeks, how much have you enjoyed sexual intercourse?

- ☐ No intercourse
- ☐ Very highly enjoyable
- ☐ Highly enjoyable
- ☐ Fairly enjoyable



- ☐ Not very enjoyable
- ☐ Not enjoyable

9. Over the past 4 weeks, when you had sexual stimulation or intercourse how often did you ejaculate?

- ☐ Did not attempt intercourse
- ☐ Almost always or always
- ☐ Most times (more than half the time)
- ☐ Sometimes (about half the time)
- ☐ A few times (much less than half the time)
- ☐ Almost never or never

10. Over the past 4 weeks, when you had sexual stimulation or intercourse how often did you have the feeling of orgasm or climax (with or without ejaculation)?

- ☐ No sexual stimulation or intercourse
- ☐ Almost always or always
- ☐ Most times (much more than half the time)
- ☐ Sometimes (about half the time)
- ☐ A few times (much less than half the time)
- ☐ Almost never or never

Questions 11 and 12 ask about sexual desire. Let's define sexual desire as a feeling that may include wanting to have a sexual experience (for example, masturbation or intercourse), thinking about having sex or feeling frustrated due to a lack of sex.

11. Over the past 4 weeks, how often have you felt sexual desire?

- ☐ Almost always or always
- ☐ Most times (much more than half the time)
- ☐ Sometimes (about half the time)
- ☐ A few times (much less than half the time)
- ☐ Almost never or never

12. Over the past 4 weeks, how would you rate your level of sexual desire?

- ☐ Very high
- ☐ High
- ☐ Moderate
- ☐ Low
- ☐ Very low or none at all

13. Over the past 4 weeks, how satisfied have you been with your overall sex life?

- ☐ Very satisfied
- ☐ Moderately satisfied
- ☐ About equally satisfied and dissatisfied
- ☐ Moderately dissatisfied

☐ Very dissatisfied

14. Over the past 4 weeks, how satisfied have you been with your sexual relationship with your partner?

- ☐ Very satisfied
- ☐ Moderately satisfied
- ☐ About equally satisfied and dissatisfied
- ☐ Moderately dissatisfied
- ☐ Very dissatisfied

15. Over the past 4 weeks, how do you rate your confidence that you can get and keep your erection?

- ☐ Very high
- ☐ High
- ☐ Moderate
- ☐ Low
- ☐ Very low

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