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Modulation of late positive potentials by sexual images in problem users and controls inconsistent with "porn addiction"

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ABSTRACT

"Excessive" viewing of visual sexual stimuli (VSS) is the most commonly reported hypersexual behavior problem and is especially amenable to laboratory study. A pattern of enhanced sexual cue responsiveness is expected in this sample if hypersexuality shares features of other addiction models. Participants ($N = 122$) who either reported or denied problematic VSS use were presented with emotional, including explicit sexual, images while their evoked response potentials were recorded. An interaction of hypersexual problem group and the level of desire for sex with a partner predicted LPP amplitude. Specifically, those reporting problems regulating their VSS use who also reported higher sexual desire had lower LPP in response to VSS. This pattern appears different from substance addiction models. These are the first functional physiological data of persons reporting VSS regulation problems.

1. Introduction

"Addiction" is used to refer to high frequency sexual behaviors in about 37% of research articles (Mudry et al., 2011). Yet, theoretical models of visual sexual stimulus (VSS) problems have been poorly specified (Ley, Prause, & Finn, 2014). For example, Coleman (1987) suggested a compulsivity model, but specific predictions have not been tested. VSS use problems are amenable to study and remain the most common high frequency sexual problem reported (Reid et al., 2012b). Substance addiction research suggested that addicts are especially motivated by cues of their substance. Thus, in the current study, we investigated whether neural responses to sexual cues also were greater to sex cues in those who report problems controlling their VSS use.

Although "addicts" are thought to have high sexual desire as a core feature of their difficulties, this actually is not established. Problem online erotica use was modestly related ($r = .25$) to the level of sexual arousal reported to sexual images (Brand et al., 2011). A study of 50 males identified those classified as hypersexual as reporting higher sexual arousal and desire to masturbate to sexual images than controls (Laier, Pawlikowski, Pekal, Schulte, & Brand, 2013). Those who engaged in the highest levels of "impersonal" sex (e.g., masturbation, one-time partner) in that study, reported feeling very easily sexually aroused. Contrary evidence suggests that hypersexuals may not exhibit more sexual desire. No relationship between neural (P300) responses to sexual images and three measures of hypersexuality could be identified in a study sufficiently powered to detect small effect sizes (Steele, Prause, Staley, & Fong, 2013). Another study of 120 men and women did not identify any differences in the level of sexual arousal reported to sexual films between those reporting problem use of VSS and controls (Prause, Staley, & Fong, 2013). Finally, sexual desire was related to individuals' ability to regulate their sexual arousal, whereas the level of hypersexuality was unrelated (Winters, Christoff, & Gorzalka, 2010). Thus, both VSS problems and sexual desire levels were included as predictors of neural response in the present study.

Cue-reactivity characterizes how individuals respond to cues of their substance or behavior (Drummond, 2000). Event-related potentials (ERPs) have often been used as a physiological measure of cue reactivity. ERP differences to VSS predict genital responses (Ponseti, Kropp, & Bosinski, 2009) and the number of sexual partners (Prause, Steele, Staley, & Sabatinelli, 2014).

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The late positive potential (LPP) component of the ERP has been used as an index of emotional responses (Schupp, Flaisch, Stockburger, & Junghöfer, 2006). The LPP is a late component of the ERP with central, parietal, and occipital sources when localized in EEG (Foti, Hajcak, & Dien, 2009) sensitive to motivational processes (Bradley, Hamby, Löw, & Lang, 2007; Hajcak, MacNamara, & Olvet, 2010; Schupp et al., 2000). LPP amplitude is enhanced during the presentation of both pleasant and unpleasant images relative to neutral images (Cesarei, Codispoti, Schupp, & Stegagno, 2006) and is associated with motivated and sustained attention (Hajcak, Dunning, & Foti, 2009; Schupp et al., 2000). It is correlated with activity in cortical and subcortical structures involved in emotional picture perception (Sabatinelli, Keil, Frank, & Lang, 2013; Sabatinelli, Lang, Keil, & Bradley, 2007). Also, the subcortical structures involved in LPP modulation differ for unpleasant, as compared to pleasant, stimuli (Liu, Huang, McGinnis-Deweese, Keil, & Ding, 2012). LPP amplitude to pleasant stimuli is specifically related to higher approach motivation (Wacker, Mueller, Pizzagalli, Hennig, & Stemmler, 2013), which is not due merely to general arousal (Gable & Harmon-Jones, 2013).

The enhancement of the LPP to cues relevant to the addiction under study is well replicated. Problem gamblers show an enhanced LPP to gambling cues (Wölfling et al., 2011); problem gamers show an enhanced LPP to gaming cues (Thalemann, Wölfling, & Grüsser, 2007). This LPP pattern has also been observed in problem users of heroin (Franken, Stam, Hendriks, & van den Brink, 2003), nicotine (Littel & Franken, 2007), and cocaine users show enhanced LPP to images of cocaine (Dunning et al., 2011) and enhances during higher cocaine craving (Franken & Muris, 2006). This pattern is so well-replicated that some consider it a biomarker for disadvantageous substance choices (Moeller et al., 2012a).

Hypersensitivity to sexual reward stimuli has been proposed to underlie VSS addiction. For example, an "unrestrained dopamine crescendo" in nucleus accumbens was cited as a key target for treating internet sex addiction (p. 229, Bostwick & Bucci, 2008). Further, impulsivity is thought to be a key feature of hypersexual behaviors (Miner, Raymond, Mueller, Lloyd, & Lim, 2009; Reid, Cooper, Prause, Li, & Fong, 2012), and impulsivity is positively related to reward sensitivity (Torrubia, Ávila, Moltó, & Casera, 2001). Finally, those with more sexual intercourse partners exhibit greater LPP responses to sexually explicit images (Prause et al., 2014). However, the only study of neural sensitivity to sexual cues in those with problems regulating their viewing of VSS failed to find a relationship (Steele et al., 2013).

Sensitivity to sexual rewards has been better characterized with respect to sexual desire levels than VSS viewing problems.

Responsivity to VSS was greater in reward-related brain areas in those with higher sexual motivation (Arnow et al., 2009; Demos, Heatherton, & Kelley, 2012; Fonteille & Stoléru, 2011), although the P300 to VSS was inversely related to sexual motivation in a different sample (Steele et al., 2013). Dopamine agonists further increase neural responses to sexual stimuli, even when sexual stimuli are presented subliminally (Oei, Rombouts, Soeter, van Gerven, & Both, 2012). The specificity of cue reactivity activation to VSS for hypersexuality is unclear. For example, rodents bred for greater reward sensitization exhibit more frequent sexual behaviors (Cummings, Clinton, Perry, Akil, & Becker, 2013). Thus, studies suggest that sexual motivation increase responses to VSS, but VSS response in a control and hypersexual sample have not been published.

The current study examined the LPP in response to sexually motivating images as a neural index of sexual responsivity in those reporting VSS viewing problems. Whereas the only previous ERP study of high frequency VSS viewing (Steele et al., 2013) characterized hypersexuality dimensionally (cp., Walters, Knight, & Långström, 2011) using a within-subject control, the current study used a separate control group. Specifically, we test whether (1) a group that self-identified as having problems regulating their viewing of sexual images differs in their LPP amplitude to explicit sexual images from a control group and (2) whether differences between groups are attributable to sexual desire (dyadic or solitary) levels. Ethical approval for the study was obtained from the Idaho State University Institutional Review Board and all participants provided informed consent to participate.

2. Materials and methods

2.1. Participants

Both women ($n = 36$) and men from the community participated. All ($N = 122$) reported attraction to the opposite sex (see Table 2). The VSS problem group was recruited using advertisements requesting volunteers who were experiencing "problems regulating your viewing of sexual images". Volunteers were screened ($N = 142$) in the laboratory. They answered questions about their problems with VSS on a computer. After approximately ten volunteers completed these measures, the experimenter began reviewing the scores of the volunteers on each measure. As hypersexuality is not a codified diagnosis and we were expressly prohibited from recruiting patients, no thresholds could be used to empirically identify problem users. Those who volunteered due to feeling distressed about their use by virtue of the recruitment materials, also were required to endorse problems with VSS viewing on these empirical measures as determined by review of the experimenter. This continuous, non-threshold approach appears consistent with the dimensional nature of hypersexuality (Walters et al., 2011) and NIH working group (Insel et al., 2010). It also is supported by the largest study of a hypersexual disorder diagnosis to date: those who self-identified as having hypersexual problems were diagnosed as having hypersexual disorder by clinicians in 88% (134 of 152 referred) of cases (Reid et al., 2012b).

A comparison group of 67 men and women was recruited using advertisements for a study of "emotional response". On arrival, control participants were asked to answer a questionnaire that included "If you use pornography, how do you feel about this? Please check all that apply". They were required to select either or both of the options "I am fine with my porn use" or "I am fine with [my porn use], but my partner does not (or would not) like me using porn" to be included. Control group participants did not differ significantly from the VSS problem group in gender or age, but endorsed less VSS use, fewer sexual partners, and lower sexual desire (see Table 1) supporting the differentiation of these groups. See Section 3 below for a description of the outcome of the selection process.

2.1.1. Stimuli

Pictures ($N = 225$) were selected (Lang, Bradley, & Cuthbert, 2008; Spiering, Everaerd, & Elzinga, 2002) to represent pleasant ($N = 75$; e.g., skydiving), neutral ($N = 75$; e.g., portrait), and unpleasant ($N = 75$; e.g., mutilated body), categories.[2] Pleasant stimuli were matched on their level of general arousal with the most arousing

[2] Unpleasant: 2053, 2095, 2141, 2205, 2276, 2455, 2683, 2703, 2710, 2750, 2799, 2800, 2900, 2900.1, 3016, 3017, 3051, 3061, 3062, 3101, 3160, 3168, 3180, 3181, 3215, 3220, 3225, 3230, 3300, 3301, 3350, 3550, 6021, 6022, 6212, 6213, 6242, 6243, 6311, 6415, 6530, 6571, 6825, 6830, 6831, 6838, 8230, 9007, 9040, 9041, 9220, 9254, 9265, 9331, 9400, 9415, 9419, 9420, 9421, 9423, 9424, 9425, 9427, 9428, 9429, 9430, 9433, 9435, 9520, 9530, 9800, 9900, 9903, 9910, 9920; Neutral: 2005, 2020, 2038, 2102, 2104, 2190, 2200, 2210, 2210, 2214, 2215, 2221, 2230, 2235, 2271, 2272, 2280, 2305, 2372, 2381, 2383, 2385, 2393, 2394, 2396, 2397, 2435, 2440, 2441, 2485, 2487, 2491, 2493, 2495, 2499, 2506, 2512, 2513, 2514, 2516, 2518, 2520, 2570, 2575, 2579, 2580, 2593, 2595, 2597, 2600, 2620, 2635, 2690, 2695, 2702, 2749, 2752, 2810, 2830, 2840, 2850, 2870, 2890, 4000, 4571, 4605, 7493, 7496, 7506, 7550, 8010, 8241, 8311, 9070, 9700; Pleasant non-sexual: 1340, 1999, 2040, 2058, 2071, 2080, 2150, 2160,