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Neural correlates of subliminally presented visual sexual stimuli

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ABSTRACT

In the context of forensic psychiatry, it is crucial that diagnoses of deviant sexual interests are resistant to manipulation. In a first attempt to promote the development of such tools, the current fMRI study focusses on the examination of hemodynamic responses to preferred, in contrast to non-preferred, sexual stimuli with and without explicit sexual features in 24 healthy heterosexual subjects. The subliminal stimulus presentation of sexual stimuli could be a new approach to reduce vulnerability to manipulation. Meaningful images and scrambled images were applied as masks. Recognition performance was low, but interestingly, sexual preference and explicitness modulated stimulus visibility, suggesting interactions between networks of sexual arousal and consciousness. With scrambled masks, higher activations for sexually preferred images and for explicit images were found in areas associated with sexual arousal (Stoleru, Fonteille, Cornelis, Joyal, & Moulier, 2012). We conclude that masked sexual stimuli can evoke activations in areas associated with supraliminal induced sexual arousal.

1. Introduction

1.1. Neurobiological correlates of sexual arousal and preference

Human sexual arousal is caused by stimuli which are perceived as sexually preferred, evoking reactions in physiological, psychological and behavioral components (Janssen & Everaerd, 1993; Rosen & Beck, 1988). Referring to associated brain areas, four excitatory components (cognitive, motivational, emotional and autonomic) as well as an inhibitory component can be distinguished in response to visual sexual stimuli (Stoleru, Fonteille, Cornelis, Joyal, & Moulier, 2012). On the basis of PET and fMRI studies, Stoléru and colleagues assigned brain areas to these components.

Several functional imaging studies were interested in neural networks associated with sexual preference in healthy subjects. According to Ponseti et al. (2006), the ventral striatum, centromedian thalamus and premotor cortex, but also posterior parietal areas respond specifically to sexually preferred stimuli. In a group of hetero- and homosexual men and women the

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thalamus and the medial orbitofrontal cortex (OFC) responded most strongly to sexually preferred faces when compared to sexually non-preferred faces (Kranz & Ishai, 2006). Safron et al. (2007) found enhanced hemodynamic responses to preferred explicit stimuli compared to non-preferred explicit stimuli in visual regions, posterior cingulate, precuneus, left superior parietal lobule, left globus pallidus, thalamus, left putamen, left insula, bilateral caudate, left claustrum, left amygdala, anterior cingulate, hypothalamus, nucleus accumbens/subcallosal cortex, left superior frontal gyrus, and left cerebellum. Interestingly, Paul et al. (2008) showed that film excerpts opposite to the sexual orientation of the subjects evoked hemodynamic responses in brain regions associated with intense (aversive) autonomic and emotional responses (e.g. bilateral insula, amygdala). However, the hypothalamus was more strongly activated when sexual orientation of subjects and video content were matched, indicating its function as a key structure regarding sexual preference. It should be noted, however, that neural activation in the hypothalamus was only found when the threshold was set at a lenient $p < 0.05$ (uncorrected for multiple comparisons), a threshold that is usually considered as too low to protect from false positive errors. By comparing hemodynamic responses to erotic, aversive and neutral stimuli, Kagerer et al. (2011) were able to disentangle sexual from general arousal. Neural activation in thalamus, hypothalamus, occipital cortex and nucleus accumbens was found in relation to sexual arousal while enhanced activity in the insula, the amygdala and the anterior cingulate gyrus were associated with general arousal.

In summary, the thalamus and hypothalamus seem to be particularly responsive to sexually preferred stimuli. Other structures occasionally associated with sexual preference are posterior parietal areas, OFC, premotor cortex and ventral striatum. According to the model of Stoleru et al. (2012), these structures are assumed to be associated with cognitive, automatic and motivational components.

1.2. Subliminal processing of sexual stimuli

Following an information processing approach (Janssen, Everaerd, Spiering, & Janssen, 2000; Spiering & Everaerd, 2007), visual sexual stimuli are not only processed consciously and in a controlled manner but also subliminally and automatically. Recently, Gillath and Collins (2016) provided evidence that subliminal sexual stimuli are indeed able to induce positive affects and motivation presumably to engage in sex. The usage of subliminally presented visual sexual stimuli yields certain advantages, like preventing deliberate manipulations or other effects of conscious stimulus processing (Jordan, Fromberger, & Müller, 2015). Conscious access can be prevented by presenting stimuli below 50 ms and applying masking procedures (Brooks et al., 2012). Supporting the model by Spiering and Everaerd (2007), it was shown that subliminally presented sexual primes elicit erectile responses (Janssen et al., 2000) and also facilitate the identification of sexual targets (Spiering, Everaerd, & Janssen, 2003). Otherwise, experience of subjective arousal seems to require conscious elaboration of sexual stimuli (Gillath, Mikulincer, Birnbaum, & Shaver, 2007; Spiering et al., 2003).

To our knowledge, only a few imaging studies examined the hemodynamic responses to subliminal presentation of visual sexual stimuli (Childress et al., 2008; Gillath & Canterberry, 2012; Jordan, Fromberger, Laubinger, Dechent, & Müller, 2014; Oei, Both, van Heemst, & van der Grond, 2014; Oei, Rombouts, Soeter, van Gerven, & Both, 2012). In 22 male patients masked images of erotic couples evoked stronger hemodynamic responses in the amygdala, ventral striatum/pallidum, the orbitofrontal cortex, anterior and posterior insula, temporal poles and in the hypothalamus compared to neutral images (Childress et al., 2008). Gillath and Canterberry (2012) found stronger hemodynamic responses for sexual cues in the inferior, superior, middle and medial frontal regions, in the inferior and superior parietal lobule, the middle occipital and temporal regions, the parahippocampal and postcentral gyri, posterior cingulate, precuneus and thalamus. Oei et al. (2012) reported stronger hemodynamic responses in the insula, the left and right OFC, the caudate nucleus and the nucleus accumbens, paracingulate gyrus and the bilateral occipital cortex when compared the subliminal presentation of sexual stimuli with neutral stimuli. In a subsequent study, Oei et al. (2014) were able to replicate these results to a great extent. In contrast to masked neutral stimuli, masked sexual stimuli induced enhanced activation in the left OFC with local maxima in the insula, thalamus, nucleus accumbens (bilaterally) and the amygdala. Furthermore, clusters in the anterior cingulate cortex, precuneus and right insula were found. In a single case study, Jordan et al. (2014) found changed activation pattern evoked by sexually preferred stimuli after antiandrogen therapy in occipital and parietal brain regions, the orbitofrontal cortex and the hippocampus. Recently, Ito et al. (2015) examined neuronal effects of subliminally presented preferred faces over non-preferred faces and found clusters in the dorsomedial, ventrolateral and dorsolateral prefrontal cortex. The authors also applied a supraliminal condition and found enhanced hemodynamic responses to preferred faces in the ventrolateral prefrontal cortex, the ventral striatum and the superior temporal gyrus.

In summary, these studies showed that subliminally presented visual sexual stimuli can evoke brain activations in regions known to be activated in response to other categories of subliminally presented arousing stimuli, e.g. in the occipital cortex, amygdala, insula and also in the cingulate cortex (Brooks et al., 2012). Furthermore, activations in the OFC and in frontal, temporal, parahippocampal and parietal regions were reported.

1.3. Objective and hypotheses

In a first attempt to promote the development of a fraud-proof tool for diagnosing deviant sexual interest, the current study focused on the examination of sexual preference using subliminal stimulus presentation. The forensic sector or legal settings especially, in which deviant sexual interest plays an important role (e.g. deviant sexual interest in children), are con-