MASTER DEGREE IN PSYCHOLOGY
PSYCHOLOGY OF JUSTICE AND DEVIANT BEHAVIOUR

Aroused and Mind-Wondering: EEG connectivity pattern of the Default Mode Network during free viewing of sexually explicit video

Camila Patrícia de Soares Comprido

M

2022

University of Porto

Faculty of Psychology and Education Sciences

AROUSED AND MIND-WONDERING: EEG CONNECTIVITY PATTERN OF THE DEFAULT MODE NETWORK DURING FREE VIEWING OF SEXUALLY EXPLICIT VIDEO

Camila Patrícia de Soares Comprido

October 2022

Dissertation presented to the Faculty of Psychology and Education Sciences of the University of Porto, to obtain the Master's degree in Psychology under the orientation of Dr. Nicoletta Cera, Ph.D (FPCEUP).

LEGAL NOTICES

The content of this dissertation reflects the perspectives, the work, and the author's interpretations at the time of delivery. This dissertation may contain inaccuracies, both conceptual as methodological, which may have been identified later than delivery. Therefore, any use of its contents should be exercised with caution.

In delivering this dissertation, the author declares that it is the result of his own work, contains original contributions and are recognized all sources used. These sources are duly cited in the body of the text and identified in the section references. The author also declares that does not disclose in this dissertation any content whose reproduction is prohibited by copyright or industrial property.

Abstract

The DMN can be considered one of the most studied resting-state networks (RSNs). This network comprises principal hubs, the medial prefrontal cortex (mPFC) and the posterior cingulate cortex (PCC) and plays a role in self-referential processing. A previous study assessed functional connectivity modifications in the DMN hubs during passive viewing of long-VSS in erectile dysfunction patients, hypothesizing a possible role played by the DMN in autobiographical memory related to explicit sexual contexts. However, little is known about functional connectivity modifications of EEG power spectra in the DMN and sexually aroused states in terms of power spectra analysis in women. In this study, 10 women with no sexual dysfunctions or history of general medical diseases engaged in the free viewing of a long erotic clip while their EEG was recorded. The erotic stimuli presented was divided in 4 phases that corresponded to sexual interactions presented. 19 electrodes to access DMN activity. DMN power spectra correlations for each phase were more significant for beta power frequency band over central, parietal, and occipital sites. Internal self-related processing associated to DMN activity might be present during sexual aroused states in women. This potential link needs to be further investigated.

Keywords: DMN; EEG; sexual arousal; power spectrum; women.

Resumo

O DMN pode ser considerado uma das redes de *resting state* (RSNs) mais estudadas. Esta rede compreende como principais hubs, o córtex pré-frontal medial (mPFC) e o córtex cingulado posterior (PCC) e por isso desempenha um papel no processamento autorreferencial. Um estudo anterior avaliou modificações da conectividade funcional nos *hubs* do DMN durante a visualização passiva de um vídeo erótico em pacientes com disfunção erétil, destacando um possível papel desempenhado pelo DMN na memória autobiográfica relacionada a contextos sexuais explícitos. No entanto, pouco se sabe sobre as modificações de conectividade funcional dos EEG *power spectrum* no DMN e estados de *arousal* sexual em mulheres. Neste estudo, 10 mulheres sem disfunções sexuais ou histórico de doenças médicas gerais participaram na visualização de um longo vídeo erótico enquanto a sua atividade EEG foi gravada. O estímulo erótico apresentado foi dividido em 4 fases que corresponderam a interações sexuais representadas no vídeo. 19 elétrodos considerados como correspondentes às zonas de ativação dos DMN *hubs* foram selecionados. As correlações obtidas dos power spectrum DMN para cada fase foram mais significativas para a banda de frequência beta sobre os elétrodos central, parietal e occipital. O processamento autorreferencial interno associado à atividade dos *hubs* do DMN pode estar presente durante os estados de *arousal* sexual em mulheres. Esta relação potencial precisa de ser investigada mais profundamente.

Palavras-chave: DMN; EEG; excitação sexual; power spectrum; mulheres.

Résumé

Le DMN peut être considéré comme l'un des *resting state networks* (RSNs) les plus étudiés. Ce réseau comprend comme principaux hubs, le cortex préfrontal médial (mPFC) et le cortex cingulaire postérieur (PCC) et joue donc un rôle dans le traitement autoréférentiel. Une étude antérieure a évalué les modifications de la connectivité fonctionnelle dans les *hubs* DMN lors de la visualisation passive d'une vidéo érotique chez les patients souffrant de dysfonction érectile. Soulignant un rôle possible joué par le DMN dans la mémoire autobiographique liée aux contextes sexuels explicites. Cependant, on sait peu de choses sur les modifications de la connectivité fonctionnelle des EEG power spectrum dans le DMN et les états d'arousal sexuel chez les femmes. Dans cette étude, 10 femmes sans dysfonctionnements sexuels ou antécédents de maladies médicales générales ont participé à la visualisation d'une longue vidéo érotique pendant que leur activité EEG était enregistrée. Le stimulus érotique présenté a été divisé en 4 *phases* correspondant à des interactions sexuelles représentées. 19 électrodes correspondant aux zones d'activation des *hubs* DMN ont été sélectionnées. Les corrélations obtenues des power spectrum DMN pour chaque phase étaient plus significatives pour la bande de fréquence bêta sur les sites central, pariétal et occipital. Le traitement autoréférentiel interne associer à l'activité des *hubs* DMN peut être présent pendant les états excités sexuels chez les femmes. Cette relation potentielle doit être étudiée plus en profondeur.

Mots-clés : DMN; EEG; excitation sexuelle; power spectrum; femmes.

Table of Contents

Table of Acronyms

AG Angular Gyrus

ACC Anterior Cingulate Cortex

BDI Beck Depression Inventory

BOLD Blood Oxygen Level-Dependent Signal

dB Decibel

DMN Default Mode Network

EEG Electroencephalography

ERPs Event Related Potential

FFSI Female Sexual Function Index

fMRI Functional Magnetic Resonance Imaging

ICA Independent Component Analysis

IPL Inferior Parietal Lobule

mPFC Medial Prefrontal Cortex

PHG Parahippocampal Gyrus

PERT Post-Ejaculatory Refractory Period

PCC Posterior Cingulate Cortex

PCUN/PCC Precuneus-Posterior Cingulate Cortex

RSN Resting State Networks

SN Salience Network

SD Standard-Deviation

VI Vaginal Intercourse

VSS Visual Sexual Stimulation

Index of Tables

Table 13. T-test comparison of the r-to-z Fisher Transformation results between Vaginal Intercourse and Orgasm Epochs for Delta Power

Introduction

During the last years, several studies investigated the brain bases of cognitive and emotional functions, discovering a set of brain networks. Resting state networks (RSN) can be characterised in terms of low frequency (0.01-0.1Hz) of blood oxygen level-dependent signal (BOLD), as studied with functional Magnetic Resonance Imaging (fMRI) and overlap with other networks that are present during active behavioural tasks (Mantini et al., 2007; Fox et al., 2005). Default Mode Network (DMN – Fox et al., 2005; Seitzman et al., 2019) can be considered one of the most studied networks. Overall, the DMN plays a role in self-referential processing and introspection (Greicius et al., 2002; Buckner, 2008; Knyazev, 2013; Smitha et al., 2017; Seitzman et al., 2019). The hubs of DMN involve the medial prefrontal cortex (mPFC) and the posterior cingulate cortex (PCC-Buckner et al., 2008). The first represents an anterior DMN hub including part of the anterior cingulate cortex (ACC), and frontal lobe. The second represents the posterior DMN hub, including the precuneus-PCC (PCUN/PCC) and retrosplenial cortex (Andrews-Hanna et al., 2010; Buckner et al., 2008). Lateral nodes include the inferior parietal lobule (IPL), the angular gyrus (AG), and the medial temporal regions, mainly the parahippocampal gyrus (PHG - Andrews-Hanna et al., 2010; Nair et al., 2020). As reviewed by Rushworth et al (2011) and later by Euston et al (2012) the mPFC plays a role in decision-making which includes reward-guided learning or value encoding, and it also has been related to memory encoding and retrieval. Thus, the ventral mPFC receives information from the external world through sensory and limbic structures input and communicates with areas such as the hypothalamus facilitating adaptive decision making (Raichle, 2015). Additionally, PCC activity has been related to the retrieval of episodic memories, associated with emotional awareness

(Greicius et al., 2002; Imperatori et al., 2016). This enhances, as reviewed by Raichle (2015), the link of the DMN with social behaviour, mood control and motivational drive.

As above mentioned, regions of the DMN, specifically the ACC and ventral mPFC seem to be involved in autonomic regulation which might be linked to sexual arousal (Stoléru et al., 2012) and communicate with brain regions that mediate intrinsic homeostatic drive (Raichle, 2015), respectively. Sexual arousal is related to the physiological response since sexual response comprises excitatory and inhibitory mechanisms that help in the regulation of sexual responsiveness, and the subjective pleasure experience (Georgiadis, 2015; Calabrò et al., 2019). According to Georgiadis (2015), the stages of the human sexual response can be conceived as “the sexual pleasure cycle” which distinguishes between different systems, or stages, inspired by the reward system approach to other pleasure-seeking behaviours, such as eating. Neuroimaging techniques have been used to investigate cortical and subcortical brain regions involved in the sustaining or switching between phases of this pleasure cycle. Georgiadis and Kringelbach’s review (2012) and later Calàbro et al., review (2019) point out the “sexual wanting” pattern which includes the superior parietal lobule, temporo-occipital areas; and the “sexual liking” pattern which includes the IPL, hypothalamus, ventral premotor cortex, and the middle cingulate cortex. The last system is the “inhibition” which brings the system back to the baseline, at least in men orgasm is followed by a post-ejaculatory refractory period (PERT) that corresponds to a satiety phase (Georgiadis & Kringelbach, 2012; Georgiadis, 2015).

Modifications of brain networks, such as DMN and salience network (SN) in psychogenic erectile dysfunction patients compared to healthy controls, were assessed during free viewing of an erotic video clip. During passive viewing of 8 minute-erotic video, the DMN showed a decreased functional connectivity in the patient group, specifically in the mPFC, PCC, PCUN and the left IPL (Cera et al., 2014), allowing a role played by DMN in the perspective taking, empathy and autobiographical memories related to explicit sexual contexts. Previous neuroimaging studies hypothesised the presence of brain areas of overlap in men and women in response to erotic films such as, the anterior cingulate, mPFC, orbital prefrontal cortex, (Ponseti et al., 2006; Rupp & Wallen, 2007). Conversely, the female sexual response can be influenced by hormonal changes in the menstrual cycle, more relevant in regions such as OFC, amygdala, and cingulate cortex (Georgiadis & Kringelbach, 2012). According to a recent review, (van't Hof & Cera, 2021), only few studies investigated the brain underpinning of sexual behaviour and arousal in women. The study of the female sexual brain allowed a series of methodological challenges mainly due to the complexity of sexual response and genital arousal. Moreover, during the last years and thanks to advances in the fMRI, only few studies investigated the neuroelectric correlates of female sexual behaviour. As highlighted by Ziogas et al. (2020), despite one of the first EEG study was a case report about an epileptic woman with sexual manifestation (Bente & Kluge, 1953), most of the studies reported Event related potential (ERPs) results mainly using static sexual stimuli like photos or images. Thus, ERPs allow the study of the processes underlying sexual behaviour in the order of milliseconds, relevant for the very early components related to the processing of sexual stimuli. Despite this relevance, EEG can allow at disentangling the brain processes and the role played by the brain networks during the resting state and during natural vision (i.e., cinema viewing - Pamilo et al., 2012)

Electroencephalographic (EEG) and functional neuroimaging studies assessed the relationship between neuronal oscillatory power variations of rhythms and BOLD signal fluctuations associated with RSNs, respectively. In these studies, regions of the DMN positively correlated with alpha (8-13Hz) and beta (15-25Hz) rhythms (Mantini et al., 2007; Hlinka et al., 2010). Alpha rhythms have been associated with working memory functions and short-term memory, and beta rhythms were related to maintenance of motor sets and cognition (Neuner et al., 2014). DMN activity was associated with alpha increased activity over central electrodes and posterior occipital electrodes. It was also associated with increased beta activity over parietal electrodes (Jann et al., 2010; Knyazev et al., 2011; Knyazev, 2013).

Furthermore, previous EEG-fMRI studies reviewed by Knyazev (2013), reported negative correlations at frontal cortical sites between delta (0.5Hz-3.5Hz) and theta (3.5-7Hz) bands and BOLD signal of DMN (Jann et al., 2010; Knyazev, 2013). In addition, positive gamma (30-70Hz) correlations with the DMN BOLD signal were also reported (Mantini et al., 2007; Knyazev, 2013). Gamma rhythms have been associated with conscious awareness, memory encoding and retrieval (Ward, 2003), attention processes, stimulus selection and movement preparation (Neuner et al., 2014). Besides, Neuner et al (2014) reported a highly significant correlation between delta power within the DMN and the PHG. This correlation was assumed to be linked to memory retrieval during resting state (Neuner et al., 2014). In terms of oscillatory power variations of rhythms and sexually motivated states, sexual arousal was associated with the increase of delta waves (Knyazev, 2012). Whilst in another study, participants engaging in the visualization of a sexually motivating film while their EEG was recorded showed decreased alpha power, more prominent in the right hemisphere (Prause et al., 2014). Analysing spatial and temporal synchrony data over multiple frequency bands could help clarify different processes such as the emergence of memories, feelings, thoughts, and emotions

(Knyazev, 2012). Yet, little is known about the relationship between the DMN and sexually aroused states in terms of power spectra analysis, especially in women. The aim of the present study was to identify the functional connectivity modifications of EEG power spectra in the DMN during visual sexual stimulation (VSS) in women. Moreover, it is hypothesised that (1) there might be a correlation between beta power and DMN activity over parietal electrodes during free viewing of erotic videoclip and that (2) there might be a correlation between alpha power and DMN activity at central and posterior occipital sites during free viewing of erotic videoclip. Finally (3) there might be a correlation between delta power and DMN activity over tempo parietal sites during free viewing of erotic videoclip.

Materials and Methods

Participants

Participants were women recruited among the university students and using the snowball recruiting method, with age range between 23 and 55 years (N = 10; mean = 32, 8 years; *SD* = 11, 7). The exclusion criteria were history of sexual dysfunctions, history of general medical diseases (i.e., diabetes, hypertension) use of any psychoactive substances during the past two weeks. Each participant read and signed the informed consent. This study was approved by the Ethical Committee of the Faculty of Psychology and Educational Sciences of the University of Porto and conducted in accordance with the World Medical Association Declaration of Helsinki (1997). Subject intimacy was ensured by implementing the guidelines suggested by Rosen and Beck (1988). Data was collected according to the GDPR - General Data Protection Regulation approved by UE n.2016/679 on April 27th, 2016. All the participants received a compensation of 40€ in gift cards.

Questionnaires

To assess sexual behaviour and psychological dimensions, we used questionnaires adapted to the European Portuguese population. Indeed, participants underwent the sociodemographic questionnaire including age, nationality, gender, socioeconomic status, and marital status. Moreover, the Beck Depression Inventory (BDI - McIntyre & McIntyre, 1995), which is a 21-item self-report inventory in which higher scores indicate depressive symptomatology. Additionally, The Female Sexual Function Index (FFSI - Pechorro et al., 2009) is a 19-item self-report inventory to assess female sexual and genital function.

Stimuli

The selected stimuli included 3 audio-visual complex clips. Each lasting 15 minutes. The video clips were uploaded to the SMI BeGaze - Behavioural and Gaze Analysis Software on the experimental computer and presented on the stimuli monitor placed on a desk in the data collection room. The first video represented the sexual stimulus. The erotic video clip showed a consensual sexual interaction between one Caucasian man and one Caucasian woman, petting or foreplay, oral sex, and vaginal intercourse and disengagement (Cera et al., 2020; Wang et al., 2022). The second video clip represented the neutral stimulus depicting an expedition in Mongolia and Kazakhstan with relaxing classical piano music in the background (Cera et al., 2012; Wang et al., 2022). Following a negative stimulus video excerpt from the movie The Deer Hunter (Gomez et al., 2009; Wang et al., 2022). Additionally, subjects were asked to answer questions about how they felt after the visualisation of each video, according to a 7-points rating scale (1 strongly disagree and 7 strongly agree). Questions included “I felt calm”, “I felt sexually aroused”, “I felt sad”, “I recalled events from the past”. As for the erotic video clip, questions included the previous as well as “I felt aroused by the woman”, “The woman knew how to give pleasure”, “I liked the man’s body”, “I felt sexually aroused”, “I felt my heartbeat faster”, “I wanted to get sexually involved with a partner”.

Despite the complex experimental design, the present study took into consideration only the above describe sexual stimulus. Indeed, in a fMRI study, Cera et al., (2014) showed consistent involvement of DMN during long free viewing of sexual arousing video. Elicited brain networks during cinema viewing have been reported by Pamilo et al. (2012).

EEG measurements

EEG recording and equipment

To ensure the privacy of the participants, the EEG recording sessions took place in the soundproof room at SexLab at University of Porto. The room was connected to the data-collection room using an interphone to ensure that participants followed the instructions and that they did not sleep onset during the recording. Participants were seated at approximately 60 cm distance from the computer screen. The EEG session started with preparation and placement of electrodes (lasting around 30 min) and continued with the baseline recording and the VSS task, which took around 45 minutes. The current analysis has been performed on the sexual video clip lasting 15 minutes.

The EEG was recorded with a 512 Hz sampling rate, using a 32-channel portable system ANT-Neuro (ANT-Neuro, The Netherlands). The 32 electrodes were distributed across the scalp according to the extended 10–20 International system and applied using an elastic electrode cap. The ground has been positioned on the POz and two electrodes on the mastoids. Impedances were kept below 10 kΩ at all sites.

Data analysis

EEG preprocessing

The continuous EEG data were imported in EEGLAB v2021.1, compiled version for Windows (Delorme and Makeig, 2004). The averaged signal was used as off-line reference. A segment with a duration of 15 min was selected based on the EYE tracker recording. Afterwards the data were high-pass filtered at 0.5 Hz and low-pass filtered at 40 Hz. Therefore, EEG data were segmented into 4 epochs with a duration of 30 s (i.e., Petting), 390 s (i.e., Oral), 360s (i.e., Vaginal Intercourse) and 120 s (i.e., Orgasm), respectively. We visually inspected the epochs and we manually removed artifacts such as head or muscle movements, electrode cable movement and rare jaw clinching. Subsequently, we performed an Independent Component Analysis (ICA) decomposition (Makeig et al., 1997) to remove blinks, eye-movements and muscle or movement artifacts from the data.

To study functional connectivity between the nodes and the hubs of DMN across the above-described epochs, the relative spectral power in dB(decibels) has been extracted for the following channels: FP1, FP2, F7, F3, Fz, F4, F8, T7, C3, Cz, C4, T8, P7, P3, Pz, P8, O1, O2. These channels are the DMN as referenced in the 10-20 international system and adapted to the 32-channel EEG recording (Imperatori et al., 2016; Thatcher et al., 2014). The peaks of the power values were extracted for the delta (0.5–4 Hz), theta (4–8 Hz), alpha (8–13 Hz) and beta (13–30 Hz) bands. The gamma band (30–48 Hz) has been excluded from analysis. Indeed, according to Whitham et al. (2007) several artifacts such as muscle contraction and movements usually affect the gamma frequency range in EEG recordings.

Statistical analysis

To study the functional connectivity pattern of the DMN, and the role played by alpha, beta and theta power spectra, a series of Pearson's Correlations have been calculated on the extracted power peak values for the above-mentioned power spectra, during the phases of the sexual interaction as showed in the sexual video. Moreover, to perform comparison between the correlation results, a r-to- z Fisher Transformation has been applied. Then the obtained z values were introduced in a series of two-tailed t tests for statistical comparisons.

All the statistical analyses have been performed using Statistica 13 (TIBCO Software inc.) All the resulting *p* values were corrected for multiple comparisons using Bonferroni's correction.

Results

Sociodemographic and psychological data

Table 1 shows the sociodemographic data about the participants.

Table 1

Sociodemographic data

Gender	Age (in years)		Nationality	Marital Status
N (%)	Mean	SD	N (%)	N (%)
Women 10 (100%)	32,8	11,7	Portuguese 9 (90%)	Single 8 (80%)
			Other 1 (10%)	Cohabitation 1 (10%)
				Married 1 (10 %)

BDI and FSFI results are presented on Table 2 and 3, respectively. No participant showed significant scores. Therefore, all participants were considered in the analysis.

Table 2

Beck Depression Inventory results

BDI		
Mean	Mean	Mean
28.2	6.92	22-43

Table 3

Female Sexual Function Index results

FSFI (Domains)											
Desire		Arousal		Lubrification		Orgasm		Satisfaction		Pain	
Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3.78	1.23	3.72	2.13	4.38	2.39	3.52	2.39	4.40	1.50	1.86	1.15

DMN nodes power spectra correlation for each epoch

Pearson's correlation performed for each epoch revealed significant correlations (*p<0,05*) at alpha, beta, theta, and delta power bands between the phases of physical interactions between the two actors of the erotic clip (see Appendix Figure 1 and Figure 2).

T-test comparison of the r-to-z Fisher Transformation for the alpha band showed a significant correlation between the Oral and the VI (Vaginal Intercourse) phase (Table 4) with t value of $t_{(16)}=2.18$, $p=0.04$ at parietal sites.

Table 4

T-test comparison of the r-to-z Fisher Transformation results between Oral and Vaginal Intercourse Epochs for Alpha Power

Variable	Mean Oral	SD Oral	Mean VI	SD VI	t-value	df	*p*
Cz	0,47	0,48	0,28	0,50	0,85	16,00	0,41
C4	0,54	0,73	0,37	1,02	0,42	16,00	0,68
T8	0,37	0,60	0,36	0,68	0,04	16,00	0,97

Variable	Mean Oral	SD Oral	Mean VI	SD VI	t-value	df	*p*
P7	0,61	0,42	0,43	0,49	0,82	16,00	0,42
P3	0,65	0,51	0,31	0,36	1,66	16,00	0,12
Pz	**0,53**	**0,43**	**0,17**	**0,26**	**2,18**	**16,00**	**0,04**
P4	0,63	0,50	0,31	0,32	1,56	16,00	0,14
P8	0,57	0,47	0,43	0,50	0,61	16,00	0,55
O1	0,50	0,35	0,18	0,29	2,09	16,00	0,05
O2	0,64	0,52	0,27	0,30	1,89	16,00	0,08

T-test comparison of the r-to-z Fisher Transformation for beta power, correlations were significant when comparing the Petting and Oral phase (Table 5) at central ($t_{(16)}$=-3,02, *p*=0.01), parietal ($t_{(16)}$=-2,13, *p*=0,05) and occipital electrodes ($t_{(16)}$=-2,87, *p*=0,01; $t_{(16)}$=-2,41, *p*=0.03).

Table 5

T-test Comparison of the r-to-z Fisher Transformation Results between Petting and Oral Epochs for Beta Power

Variable	Mean Petting	SD Petting	Mean Oral	SD Oral	t-value	df	*p*
Cz	**0,00**	**0,28**	**0,44**	**0,34**	**-3,02**	**16,00**	**0,01**
C4	0,33	0,41	0,79	0,77	-1,60	16,00	0,13
T8	0,11	0,39	0,42	0,54	-1,38	16,00	0,19
P7	0,08	0,20	0,22	0,35	-1,00	16,00	0,33
P3	**0,04**	**0,28**	**0,42**	**0,45**	**-2,13**	**16,00**	**0,05**
Pz	0,18	0,39	0,33	0,23	-1,01	16,00	0,33
P4	0,04	0,50	0,34	0,53	-1,23	16,00	0,24
P8	0,14	0,14	0,20	0,38	-0,49	16,00	0,63
O1	**0,03**	**0,25**	**0,37**	**0,25**	**-2,87**	**16,00**	**0,01**
O2	**0,06**	**0,29**	**0,44**	**0,36**	**-2,41**	**16,00**	**0,03**

Moreover, beta power band showed significant correlations between Petting and VI phases (Table 6) over central sites ($t_{(16)}$=-6,06, *p*=0,00; $t_{(16)}$=-2,22, *p*=0,04) and parietal ($t_{(16)}$=-3,76, *p*=0,00; $t_{(16)}$=-2,33, *p*=0,03; $t_{(16)}$=-2,24, *p*=0,04; $t_{(16)}$=-3,24, *p*=0,0).

Table 6

T-test comparison of the r-to-z Fisher Transformation results between Petting and Vaginal Intercourse Epochs for Beta Power

Variable	Mean Petting	SD Petting	Mean VI	SD VI	t-value	df	*p*
Cz	**0,00**	**0,28**	**0,87**	**0,33**	**-6,06**	**16,00**	**0,00**
C4	**0,33**	**0,41**	**0,80**	**0,49**	**-2,22**	**16,00**	**0,04**
T8	0,11	0,39	0,47	0,41	-1,89	16,00	0,08
P7	0,08	0,20	0,15	0,30	-0,59	16,00	0,56
P3	**0,04**	**0,28**	**0,64**	**0,38**	**-3,76**	**16,00**	**0,00**
Pz	**0,18**	**0,39**	**0,50**	**0,17**	**-2,33**	**16,00**	**0,03**
P4	**0,04**	**0,50**	**0,52**	**0,39**	**-2,24**	**16,00**	**0,04**
P8	**0,14**	**0,14**	**0,54**	**0,35**	**-3,24**	**16,00**	**0,01**
O1	0,03	0,25	-0,01	0,26	0,32	16,00	0,75
O2	0,06	0,29	0,15	0,34	-0,60	16,00	0,56

As well as in the comparison between Petting and Orgasm phase (Table 7) at central ($t_{(16)}$=-3,85, *p*=0,00) and parietal ($t_{(16)}$=-2,76, *p*=0,01) electrodes;

Table 7

T-test comparison of the r-to-z Fisher Transformation results between Petting and Orgasm Epochs for Beta Power

Variable	Mean Petting	SD Petting	Mean Orgasm	SD Orgasm	t-value	df	*p*
Cz	**0,00**	**0,28**	**0,42**	**0,17**	**-3,85**	**16,00**	**0,00**
C4	0,33	0,41	0,68	0,46	-1,73	16,00	0,10
T8	0,11	0,39	0,25	0,51	-0,67	16,00	0,51
P7	0,08	0,20	0,30	0,30	-1,80	16,00	0,09
P3	0,04	0,28	0,23	0,25	-1,50	16,00	0,15
Pz	0,18	0,39	0,40	0,25	-1,43	16,00	0,17
P4	0,04	0,50	0,10	0,20	-0,35	16,00	0,73
P8	**0,14**	**0,14**	**0,48**	**0,34**	**-2,76**	**16,00**	**0,01**
O1	0,03	0,25	-0,01	0,32	0,28	16,00	0,79
O2	0,06	0,29	0,18	0,46	-0,65	16,00	0,52

between Oral and VI (Table 8) over central ($t_{(16)}$=-2,76, p=0,01) and occipital ($t_{(16)}$=3,14, p=0,01) sites and Oral and Orgasm (Table 9) at occipital ($t_{(16)}$=2,79, *p*=0,01) electrodes.

Table 8

T-test comparison of the r-to-z Fisher Transformation results between Oral and Vaginal Intercourse Epochs for Beta Power

Variable	Mean Oral	SD Oral	Mean VI	SD VI	t-value	df	*p*
Cz	**0,44**	**0,34**	**0,87**	**0,33**	**-2,76**	**16,00**	**0,01**
C4	0,79	0,77	0,80	0,49	-0,04	16,00	0,97
T8	0,42	0,54	0,47	0,41	-0,22	16,00	0,83
P7	0,22	0,35	0,15	0,30	0,41	16,00	0,68
P3	0,42	0,45	0,64	0,38	-1,13	16,00	0,28
Pz	0,33	0,23	0,50	0,17	-1,86	16,00	0,08
P4	0,34	0,53	0,52	0,39	-0,80	16,00	0,43
P8	0,20	0,38	0,54	0,35	-1,94	16,00	0,07
O1	0,37	0,25	-0,01	0,26	3,14	16,00	0,01
O2	0,44	0,36	0,15	0,34	1,72	16,00	0,10

Table 9

T-test comparison of the r-to-z Fisher Transformation results between Oral and Orgasm Epochs for Beta Power

Variable	Mean Oral	SD Oral	Mean Orgasm	SD Orgasm	t-value	df	*p*
Cz	0,44	0,34	0,42	0,17	0,19	16,00	0,85
C4	0,79	0,77	0,68	0,46	0,35	16,00	0,73
T8	0,42	0,54	0,25	0,51	0,67	16,00	0,51
P7	0,22	0,35	0,30	0,30	-0,54	16,00	0,60
P3	0,42	0,45	0,23	0,25	1,10	16,00	0,29
Pz	0,33	0,23	0,40	0,25	-0,61	16,00	0,55
P4	0,34	0,53	0,10	0,20	1,26	16,00	0,23
P8	0,20	0,38	0,48	0,34	-1,59	16,00	0,13
O1	**0,37**	**0,25**	**-0,01**	**0,32**	**2,79**	**16,00**	**0,01**
O2	0,44	0,36	0,18	0,46	1,32	16,00	0,21

Finally, beta power showed significant correlations between VI and Orgasm phase (Table 10) over central ($t_{(16)}$=3,72, *p*=0,00) and parietal ($t_{(16)}$=2,68, *p*=0,02; $t_{(16)}$=2,82, *p*=0,01) sites; and between petting and orgasm epochs (Table 11), mainly at temporal sites ($t_{(16)=}$3,08, p=0, 01).

Table 10

T-test comparison of the r-to-z Fisher Transformation results between Vaginal Intercourse and Orgasm Epochs for Beta Power

Variable	Mean VI	SD VI	Mean Orgasm	SD Orgasm	t-value	df	*p*
Cz	**0,87**	**0,33**	**0,42**	**0,17**	**3,72**	**16,00**	**0,00**
C4	0,80	0,49	0,68	0,46	0,52	16,00	0,61
T8	0,47	0,41	0,25	0,51	0,99	16,00	0,34
P7	0,15	0,30	0,30	0,30	-1,03	16,00	0,32
P3	**0,64**	**0,38**	**0,23**	**0,25**	**2,68**	**16,00**	**0,02**
Pz	0,50	0,17	0,40	0,25	1,08	16,00	0,30
P4	**0,52**	**0,39**	**0,10**	**0,20**	**2,82**	**16,00**	**0,01**
P8	0,54	0,35	0,48	0,34	0,38	16,00	0,71
O1	-0,01	0,26	-0,01	0,32	-0,01	16,00	0,99
O2	0,15	0,34	0,18	0,46	-0,15	16,00	0,88

Table 11

T-test comparison of the r-to-z Fisher Transformation results between Petting and Orgasm Epochs for Delta Power

Variable	Mean Petting	SD Petting	Mean Orgasm	SD Orgasm	t-value	df	*p*
Cz	0,93	0,49	0,58	0,35	1,76	16,00	0,10
C4	1,04	0,56	0,88	0,51	0,65	16,00	0,52
T8	**1,07**	**0,50**	**0,40**	**0,42**	**3,08**	**16,00**	**0,01**
P7	0,66	0,43	0,69	0,35	-0,14	16,00	0,89
P3	1,12	0,63	0,77	0,45	1,39	16,00	0,18
Pz	1,04	0,56	0,87	0,55	0,64	16,00	0,53
P4	1,06	0,61	0,78	0,44	1,13	16,00	0,28
P8	1,01	0,68	0,66	0,43	1,29	16,00	0,22
O1	1,05	0,68	0,68	0,38	1,44	16,00	0,17

Variable	Mean Petting	SD Petting	Mean Orgasm	SD Orgasm	t-value	df	*p*
O2	0,98	0,55	0,86	0,53	0,48	16,00	0,64

Theta power band showed no significant correlations between phases after computing the t-test comparison of the r-to-z Fisher Transformation. As for the delta power band, statistical analysis showed significant correlations between the oral and orgasm epochs (Table 12) at temporal sites ($t_{(16)}$=2,33, *p*=0,03),

Table 12

T-test comparison of the r-to-z Fisher Transformation results between Oral and Orgasm Epochs for Delta Power

Variable	Mean Oral	SD Oral	Mean Orgasm	SD Orgasm	t-value	df	*p*
Cz	0,77	0,54	0,58	0,35	0,88	16,00	0,39
C4	1,05	0,72	0,88	0,51	0,58	16,00	0,57
T8	**1,04**	**0,71**	**0,40**	**0,42**	**2,33**	**16,00**	**0,03**
P7	0,86	0,56	0,69	0,35	0,81	16,00	0,43
P3	1,00	0,64	0,77	0,45	0,91	16,00	0,37
Pz	0,97	0,65	0,87	0,55	0,37	16,00	0,72
P4	0,93	0,57	0,78	0,44	0,64	16,00	0,53
P8	0,98	0,65	0,66	0,43	1,22	16,00	0,24
O1	0,93	0,56	0,68	0,38	1,12	16,00	0,28
O2	0,82	0,46	0,86	0,53	-0,17	16,00	0,87

and between the VI and orgasm phase (Table 13) at temporal sites ($t_{(16)}$=2.17, *p*=0,05).

Table 13

T-test comparison of the r-to-z Fisher Transformation results between Vaginal Intercourse and Orgasm Epochs for Delta Power

Variable	Mean VI	SD VI	Mean Orgasm	SD Orgasm	t-value	df	*p*
Cz	0,81	0,47	0,58	0,35	1,18	16,00	0,26
C4	1,07	0,75	0,88	0,51	0,62	16,00	0,54

Variable	Mean VI	SD VI	Mean Orgasm	SD Orgasm	t-value	df	*p*
T8	**1,10**	**0,87**	**0,40**	**0,42**	**2,17**	**16,00**	**0,05**
P7	0,69	0,43	0,69	0,35	0,04	16,00	0,97
P3	0,83	0,50	0,77	0,45	0,29	16,00	0,78
Pz	0,91	0,52	0,87	0,55	0,18	16,00	0,86
P4	0,77	0,44	0,78	0,44	-0,04	16,00	0,97
P8	0,94	0,60	0,66	0,43	1,11	16,00	0,28
O1	0,76	0,42	0,68	0,38	0,42	16,00	0,68
O2	0,74	0,36	0,86	0,53	-0,56	16,00	0,59

Discussion

In this study, we focused on the functional connectivity modifications of EEG power spectra in the DMN nodes during the visualisation of a long erotic video clip in women. Indeed, through long-VSS and neuroimaging techniques it is possible to assess mechanisms mediating sexual desire and arousal (Georgiadis & Kringelbach, 2012). The selection criteria are based on content type, mode, and duration. Noteworthy, longer, and more explicit videos are most likely to induce higher levels of sexual arousal (Georgiadis & Kringelbach, 2012; van't Hof et al., 2021). The long sexual stimulation, by means of an 8-minute video (Cera et al., 2014), showed the involvement of DMN among the other brain networks. However, no previous studies showed the power spectra modification of DMN, and sexual arousal related to the phases of sexual interaction as depicted in the video. Overall, in the present study, we found evidence that DMNs functional connectivity pattern changes in terms of power frequency (Hz) during the free viewing of the erotic clip.

We hypothesised a correlation between beta power and DMN activity over parietal electrodes during free viewing of erotic videoclip. In fact, significant correlations were observed in the Petting and VI phase, over central and parietal sites. Thus, beta power frequency was also observed compared to other selected video-epochs, showing significant correlations between the Petting and Orgasm and VI and orgasm phase over central and parietal DMN sites. Beta power frequency bands have been related to the control cognitive and motor states (Engel & Fries, 2010).

Secondly, we hypothesised a correlation between alpha power and DMN activity at central and posterior occipital sites during free viewing of erotic videoclip. Our results showed significant correlations of alpha power band over parietal electrodes also in the Oral and VI epochs. In this way, it is possible to hypothesise a role played by the relationship between alpha and beta in the emotion simulation and, specifically, in the emotional embodiment related to the high arousing content of the stimulus. Indeed, emotion simulation has been found to involve somatosensory networks (Adolphs et al., 2000). This somatosensory engagement can explain the role played by central and parietal nodes of DMN here.

Hence, a review by Fink and Benedek (2014) on EEG alpha power band showed the alpha-power sensitivity to creativity-related tasks, relating the alpha frequency band to creative ideation, which implies memory retrieval and divergent thinking. Increased alpha-power frequency has been observed over posterior parietal and occipital sites (Fink & Benedek, 2014) and was related to other creativity-related tasks such as *imagining dancing* (see Fink et al., 2009), since increases over the parietal cortex were related to internal focus attention (Benedek et al., 2014). As above mentioned, activity over DMN hubs could be linked to spontaneous self-referential thoughts and was associated with alpha activity in posterior DMN hub (Knyazev et al., 2011).

Nevertheless, beta power also showed significant correlations at occipital sites when comparing the Oral and VI phase and the petting and oral phase. Indeed, during the VI, and the Oral phase, that can plausibly represent the onset of sexual arousal in the participants, the occipital regions with higher beta can show a diminished attentional focus to the stimulus, and a redirection of the attention to the bodily changes (Pitchford & Arnell, 2019).

Lastly, it was hypothesised that there might be a correlation between delta power and DMN activity over temporo parietal sites during free viewing of erotic videoclip. Our results showed a significant correlation between delta power frequency band at temporal sites in the VI-Orgasm and in the Oral-Orgasm phase comparison. As reviewed by Harmony (2013) delta-waves might play a role during cognitive processing, specifically in the inhibition of interferences that affect performance in mental tasks (Harmony, 2013). This implies a redirection of the attention to internal guided processes, which might be related to emotion recognition and encoding related to the temporal lobe role in emotion processing (Anderson et al., 2000; Dolcos et al., 2004).

In sum, functional connectivity modifications of EEG power spectra in the DMN nodes during the visualisation of an erotic video clip in women were found when comparing the different epochs of the videoclip. Delta and beta power frequency bands showed significant correlations between the Oral and Orgasm epochs at temporal and occipital sites, respectively. This could indicate that participants engaging in long-VSS were mainly focused on the visual and auditory stimuli during these phases of the video. As for the Oral and VI epochs, correlations were more prominent for the beta and alpha power frequency bands in the central occipital and parietal sites, respectively. These results enhance the participant's focus on the visual stimuli and information processing throughout the initial and mid phases of the long-VSS.

Finally, delta and beta power frequency bands showed significant correlations between the VI and Orgasm epochs, which correspond to the last phases of the erotic clip. In the last phases, from VI to Orgasm, it is possible to see some changes in terms of switching from external attention to internal self-related processing. Since temporal lobe function was related to emotional processing and delta can be related to internal attention guided processes and since beta switched from central occipital sites to central parietal activity, guiding the attention from the visual processing to bodily sensations. Furthermore, brain regions comprising the parietal lobule might be responsible for the recognition of somatic sensations (Goldberg, 2001) and internal representation of actions (Daprati et al., 2010), allowing body awareness and readiness for the arousal. Indeed, in a single case study, Nishibayashi et al (2011) found that a lesion in the superior parietal lobe caused asomatognosia. Asomatognosia represents a disorder of body awareness, in which it is not possible to recognize the sensations from one or more parts of the body. Similarly, the sexual inhibition was observed to involve the superior parietal cortex (Cera et al., 2012) during the onset and sustained genital responses in men during visual sexual stimulation. Given the EEG did not allow to collect information about the PCC, a DMN hub, it is possible that these above-mentioned processes can be related with its role in the self-environment relationship (Maddock et al., 2001; Mitchell, 2006).

Conclusion

Our study provides a first approach to functional connectivity modifications of EEG power spectra in the DMN during VSS in women. In summary our results showed functional connectivity modifications of EEG power spectra in the DMN nodes during the visualisation of an erotic video clip in women comparing the different epochs of the videoclip. Participants stimulated with a long-VSS were mainly focused on the visual and auditory stimuli during these phases of the video. However, it is possible to see some changes in terms of switching from external attention to internal self-related processing and embodiment during the phases of the erotic video clip. This allows a possible involvement of the DMN nodes during sexual aroused states in women.

This study is part of the PTDC/PSI-GER/30520/2017 project funded by FCT (Foundation for Science and Technology) with the acronym Neurothermosex.

References

Adolphs, R., Damasio, H., Tranel, D., Cooper, G., & Damasio, A. R. (2000, April 1). A Role for Somatosensory Cortices in the Visual Recognition of Emotion as Revealed by Three-Dimensional Lesion Mapping. *The Journal of Neuroscience*, *20*(7), 2683–2690. https://doi.org/10.1523/jneurosci.20-07-02683.2000

Anderson, A. K., Spencer, D. D., Fulbright, R. K., & Phelps, E. A. (2000). Contribution of the anteromedial temporal lobes to the evaluation of facial emotion. *Neuropsychology*, *14*(4), 526–536. https://doi.org/10.1037/0894-4105.14.4.526

Andrews-Hanna, J. R., Reidler, J. S., Sepulcre, J., Poulin, R., & Buckner, R. L. (2010, February). Functional-Anatomic Fractionation of the Brain's Default Network. *Neuron*, *65*(4), 550–562. https://doi.org/10.1016/j.neuron.2010.02.005

Benedek, M., Schickel, R. J., Jauk, E., Fink, A., & Neubauer, A. C. (2014, April). Alpha power increases in right parietal cortex reflects focused internal attention. *Neuropsychologia*, *56*, 393–400. https://doi.org/10.1016/j.neuropsychologia.2014.02.010

Bente, D., & Kluge, E. (1953, July). Sexuelle reizzustände im rahmen des Uncinatus-Syndroms [sexual arousal in the context of the uncinatus syndrome]. *Archiv Für Psychiatrie Und Nervenkrankheiten*, *190*(4), 357–376. https://doi.org/10.1007/bf01225303

Buckner, R. L., Andrews-Hanna, J. R., & Schacter, D. L. (2008). The brain's default network. *Annals of the New York Academy of Sciences*, *1124*(1), 1–38. https://doi.org/10.1196/annals.1440.011

Calabrò, R. S., Cacciola, A., Bruschetta, D., Milardi, D., Quattrini, F., Sciarrone, F., Rosa, G., Bramanti, P., & Anastasi, G. (2019). Neuroanatomy and function of human sexual behavior: A neglected or unknown issue? *Brain and Behavior*, *9*(12). https://https://doi.org/10.1002/brb3.1389

Cera, N., Castelhano, J., Oliveira, C., Carvalho, J., Quinta Gomes, A. L., Peixoto, M. M., Pereira, R., Janssen, E., Castelo-Branco, M., & Nobre, P. (2020, October 28). The role of anterior and posterior insula in male genital response and in visual attention: An exploratory multimodal fMRI study. *Scientific Reports*, *10*(1). https://doi.org/10.1038/s41598-020-74681-x

Cera, N., Delli Pizzi, S., di Pierro, E. D., Gambi, F., Tartaro, F., Vicentini, C., Galatioto, G. P., Romani, G. L., & Ferretti, A. (2012). Macrostructural alterations of subcortical grey matter in psychogenic erectile dysfunction. *PLoS ONE*, *7*(6), Article e39118.

Cera, N., di Pierro, E. D., Ferretti, A., Tartaro, A., Romani, G. L., & Perrucci, M. G. (2014). Brain networks during free viewing of complex erotic movie: New insights on psychogenic erectile dysfunction. *PLoS ONE*, *9*(8), Article e105336. https://doi.org/10.1371/journal.pone.0105336

Daprati, E., Sirigu, A., & Nico, D. (2010, February). Body and movement: Consciousness in the parietal lobes. *Neuropsychologia*, *48*(3), 756–762. https://doi.org/10.1016/j.neuropsychologia.2009.10.008

Delorme, A., & Makeig, S. (2004, March). EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *Journal of Neuroscience Methods*, *134*(1), 9–21. https://doi.org/10.1016/j.jneumeth.2003.10.009

Dolcos, F., LaBar, K. S., & Cabeza, R. (2004, June). Interaction between the Amygdala and the Medial Temporal Lobe Memory System Predicts Better Memory for Emotional Events. *Neuron*, *42*(5), 855–863. https://doi.org/10.1016/s0896-6273(04)00289-2

Engel, A. K., & Fries, P. (2010, April). Beta-band oscillations — signalling the status quo? *Current Opinion in Neurobiology*, *20*(2), 156–165. https://doi.org/10.1016/j.conb.2010.02.015

Euston, D., Gruber, A., & McNaughton, B. (2012, December). The Role of Medial Prefrontal Cortex in Memory and Decision Making. *Neuron*, *76*(6), 1057–1070. https://doi.org/10.1016/j.neuron.2012.12.002

Fink, A., & Benedek, M. (2014, July). EEG alpha power and creative ideation. *Neuroscience &Amp; Biobehavioral Reviews*, *44*, 111–123. https://doi.org/10.1016/j.neubiorev.2012.12.002

Fink, A., Graif, B., & Neubauer, A. C. (2009, July). Brain correlates underlying creative thinking: EEG alpha activity in professional vs. novice dancers. *NeuroImage*, *46*(3), 854–862. https://doi.org/10.1016/j.neuroimage.2009.02.036

Fox, M. D., Snyder, A. Z., Vincent, J. L., Corbetta, M., van Essen, D. C., & Raichle, M. E. (2005). From the cover: The human brain is intrinsically organized into dynamic, anticorrelated functional networks. *Proceedings of the National Academy of Sciences*, *102*(27), 9673–9678. https://doi.org/10.1073/pnas.0504136102

Georgiadis, J. R. (2015, March 2). Functional neuroanatomy of human cortex cerebri in relation to wanting sex and having it. *Clinical Anatomy*, *28*(3), 314–323. https://doi.org/10.1002/ca.22528

Georgiadis, J. R., & Kringelbach, M. (2012). The human sexual response cycle: Brain imaging evidence linking sex to other pleasures. *Progress in Neurobiology*, *98*(1), 49–81. https://doi.org/10.1016/j.pneurobio.2012.05.004

Goldberg, M. (2001). Parietal Lobe. *International Encyclopedia of the Social &Amp; Behavioral Sciences*, 11051–11054. https://doi.org/10.1016/b0-08-043076-7/03471-9

Gomez, P., Zimmermann, P. G., Guttormsen Schär, S., & Danuser, B. (n.d.). Valence lasts longer than arousal: Persistence of induced moods as assessed by psychophysiological measures. *Journal of Psychophysiology*, *23*(1), 7.

Greicius, M. D., Krasnow, B., Reiss, A. L., & Menon, V. (2002, December 27). Functional connectivity in the resting brain: A network analysis of the default mode hypothesis. *Proceedings of the National Academy of Sciences*, *100*(1), 253–258. https://doi.org/10.1073/pnas.0135058100

Greicius, M. D., Srivastava, G., Reiss, A. L., & Menon, V. (2004). Default-mode network activity distinguishes alzheimer’s disease from healthy aging: Evidence from functional MRI. *Proceedings of the National Academy of Sciences*, *101*(13), 4637–4642. https://doi.org/10.1073/pnas.0308627101

Harmony, T. (2013). The functional significance of delta oscillations in cognitive processing. *Frontiers in Integrative Neuroscience*, *7*. https://doi.org/10.3389/fnint.2013.00083

Hlinka, J., Alexakis, C., Diukova, A., Liddle, P. F., & Auer, D. P. (2010). Slow EEG pattern predicts reduced intrinsic functional connectivity in the default mode network: An inter-subject analysis. *NeuroImage*, *53*(1), 239–246. https://doi.org/10.1016/j.neuroimage.2010.06.002

Imperatori, C., della Marca, G., Brunetti, R., Carbone, G. A., Massullo, C., Valenti, E. M., Amoroso, N., Maestoso, G., Contardi, A., & Farina, B. (2016). Default mode network alterations in alexithymia: an EEG power spectra and connectivity study. *Scientific Reports*, *6*(1). https://doi.org/10.1038/srep36653

Jann, K., Kottlow, M., Dierks, T., Boesch, C., & Koenig, T. (2010). Topographic electrophysiological signatures of fMRI resting state networks. *PLoS ONE*, *5*(9), Article e12945. https://doi.org/10.1371/journal.pone.0012945

Knyazev, G. G. (2012, January). EEG delta oscillations as a correlate of basic homeostatic and motivational processes. *Neuroscience &Amp; Biobehavioral Reviews*, *36*(1), 677–695. https://doi.org/10.1016/j.neubiorev.2011.10.002

Knyazev, G. G. (2013). EEG Correlates of Self-Referential Processing. *Frontiers in Human Neuroscience*, *7*. https://doi.org/10.3389/fnhum.2013.00264

Knyazev, G. G., Slobodskoj-Plusnin, J. Y., Bocharov, A. V., & Pylkova, L. V. (2011, July). The default mode network and EEG alpha oscillations: An independent component analysis. *Brain Research*, *1402*, 67–79. https://doi.org/10.1016/j.brainres.2011.05.052

Maddock, R., Garrett, A., & Buonocore, M. (2001, June). Remembering familiar people: the posterior cingulate cortex and autobiographical memory retrieval. *Neuroscience*, *104*(3), 667–676. https://doi.org/10.1016/s0306-4522(01)00108-7

Makeig, S., Jung, T. P., Bell, A. J., Ghahremani, D., & Sejnowski, T. J. (1997, September 30). Blind separation of auditory event-related brain responses into independent components. *Proceedings of the National Academy of Sciences*, *94*(20), 10979–10984. https://doi.org/10.1073/pnas.94.20.10979

McIntyre, T., & McIntyre, S. (1995). Inventory of beck depression: Portuguese version. *Braga: Universidade Do Minho*.

Mantini, D., Perrucci, M. G., del Gratta, C., Romani, G. L., & Corbetta, M. (2007). Electrophysiological signatures of resting-state networks in the human brain. *Proceedings of the National Academy of Sciences*, *104*(32), 13170–13175. https://doi.org/10.1073/pnas.0700668104

Mitchell, J. P. (2006). Mentalizing and marr: An information processing approach to the study of social cognition. *Brain Res*, *1079*(1), 66–75. https://doi.org/10.1016/j.brainres.2005.12.113

Nair, A., Jolliffe, M., Lograsso, Y. S. S., & Bearden, C. E. (2020). A review of default mode network connectivity and its association with social cognition in adolescents with autism spectrum disorder and Early-Onset psychosis. *Frontiers in Psychiatry*, *11*. https://doi.org/10.3389/fpsyt.2020.00614

Neuner, I., Arrubla, J., Werner, C. J., Hitz, K., Boers, F., Kawohl, W., & Shah, N. J. (2014). The default mode network and EEG regional spectral power: A simultaneous fMRI-EEG study. *PLoS ONE*, *9*(2), Article e88214. https://doi.org/10.1371/journal.pone.0088214

Nishibayashi, H., Nakai, Y., Tamura, M., Ogura, M., Uematsu, Y., & Itakura, T. (2011, January). Ictal asomatognosia due to dominant superior parietal cortical dysplasia. *Journal of Clinical Neuroscience*, *18*(1), 141–142. https://doi.org/10.1016/j.jocn.2010.04.043

Pamilo, S., Malinen, S., Hlushchuk, Y., Seppä, M., Tikka, P., & Hari, R. (2012, July 30). Functional Subdivision of Group-ICA Results of fMRI Data Collected during Cinema Viewing. *PLoS ONE*, *7*(7), e42000. https://doi.org/10.1371/journal.pone.0042000

Pechorro, P., Diniz, A., Almeida, S., & Vieira, R. (2013, April 25). Validação portuguesa do índice de Funcionamento Sexual Feminino (FSFI). *Laboratório De Psicologia*, *7*(1). https://doi.org/10.14417/lp.684

Pitchford, B., & Arnell, K. M. (2019, October). Resting EEG in alpha and beta bands predicts individual differences in attentional breadth. *Consciousness and Cognition*, *75*, 102803. https://doi.org/10.1016/j.concog.2019.102803

Ponseti, J., Bosinski, H. A., Wolff, S., Peller, M., Jansen, O., Mehdorn, H. M., Büchel, C., & Siebner, H. R. (2006, November). A functional endophenotype for sexual orientation in humans. *NeuroImage*, *33*(3), 825–833. https://doi.org/10.1016/j.neuroimage.2006.08.002

Prause, N., Staley, C., & Roberts, V. (2014, January 27). Frontal alpha asymmetry and sexually motivated states. *Psychophysiology*, *51*(3), 226–235. https://doi.org/10.1111/psyp.12173

Raichle, M. E. (2015, July 8). The Brain's Default Mode Network. *Annual Review of Neuroscience*, *38*(1), 433–447. https://doi.org/10.1146/annurev-neuro-071013-014030

Rosen, R. C., & Beck, R. C. (1988). Concerns involving human subjects in sexual psychophysiology. In *Patterns of sexual arousal: Psychophysiological processes & clinical applications* (pp. 345–355). New York: Guilford.

Rupp, H. A., & Wallen, K. (2007, August 1). Sex Differences in Response to Visual Sexual Stimuli: A Review. *Archives of Sexual Behavior*, *37*(2), 206–218. https://doi.org/10.1007/s10508-007-9217-9

Rushworth, M., Noonan, M., Boorman, E., Walton, M., & Behrens, T. (2011, June). Frontal Cortex and Reward-Guided Learning and Decision-Making. *Neuron*, *70*(6), 1054–1069. https://doi.org/10.1016/j.neuron.2011.05.014

Seitzman, B. A., Snyder, A. Z., Leuthardt, E. C., & Shimony, J. S. (2019). The state of resting state networks. *Topics in Magnetic Resonance Imaging: TMRI*, *28*(4), 189–196.

Smitha, K., Akhil Raja, K., Arun, K., Rajesh, P., Thomas, B., Kapilamoorthy, T., & Kesavadas, C. (2017). Resting-state fMRI: A review on methods in resting-state connectivity analysis and resting-state networks. *The Neuroradiology Journal*, *30*(4), 305–317. https://doi.org/10.1177/197140091769734

Stoléru, S., Fonteille, V., Cornélis, C., Joyal, C., & Moulier, V. (2012, July). Functional neuroimaging studies of sexual arousal and orgasm in healthy men and women: A review and meta-analysis. *Neuroscience &Amp; Biobehavioral Reviews*, *36*(6), 1481–1509. https://doi.org/10.1016/j.neubiorev.2012.03.006

Thatcher, R. W., North, D. M., & Biver, C. J. (2014, July 23). LORETA EEG phase reset of the default mode network. *Frontiers in Human Neuroscience*, *8*. https://doi.org/10.3389/fnhum.2014.00529

van ’t Hof, S. R., Van Oudenhove, L., Janssen, E., Klein, S., Reddan, M. C., Kragel, P. A., Stark, R., & Wager, T. D. (2021, December 16). The brain activation-based sexual image classifier (BASIC): a sensitive and specific fMRI activity pattern for sexual image processing. *Cerebral Cortex*, *32*(14), 3014–3030. https://doi.org/10.1093/cercor/bhab397

Wang, N., Pugliese, G., Carrito, M., Moura, C., Vasconcelos, P., Cera, N., Li, M., Nobre, P., Georgiadis, J. R., Schubert, J. K., & Williams, J. (2022, April 15). Breath chemical markers of sexual arousal in humans. *Scientific Reports*, *12*(1). https://doi.org/10.1038/s41598-022-10325-6

Ward, L. M. (2003, December). Synchronous neural oscillations and cognitive processes. *Trends in Cognitive Sciences*, *7*(12), 553–559. https://doi.org/10.1016/j.tics.2003.10.012

Whitham, E. M., Pope, K. J., Fitzgibbon, S. P., Lewis, T., Clark, C. R., Loveless, S., Broberg, M., Wallace, A., DeLosAngeles, D., Lillie, P., Hardy, A., Fronsko, R., Pulbrook, A., & Willoughby, J. O. (2007, August). Scalp electrical recording during paralysis: Quantitative evidence that EEG frequencies above 20Hz are contaminated by EMG. *Clinical Neurophysiology*, *118*(8), 1877–1888. https://doi.org/10.1016/j.clinph.2007.04.027

World Medical Association Declaration of Helsinki. Recommendations guiding physicians in biomedical research involving human subjects. (1997). *JAMA*, *277*(11), 925–926.

Ziogas, A., Habermeyer, E., Santtila, P., Poeppl, T. B., & Mokros, A. (2020, February 3). Neuroelectric Correlates of Human Sexuality: A Review and Meta-Analysis. *Archives of Sexual Behavior*. https://doi.org/10.1007/s10508-019-01547-3