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Social mentalizing in male perpetrators of intimate partner violence against women is associated with resting-state functional connectivity of the Crus II

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A R T I C L E I N F O

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A B S T R A C T

Social mentalizing refers to the ability to understand the intentions, causes, emotions and beliefs of another person or the self and is crucial for interpersonal understanding. Disturbances in this process may lead to aggressive and violent behaviors. Literature has shown that male perpetrators convicted for intimate partner crime (IPVAW) present alterations in different measures related to social mentalizing, in particular, they present more irrational thoughts toward women and difficulties in emotional recognition and empathy processes. However, the brain mechanisms underlying this process are still unknown. The aim of this study is to examine the resting-state functional connectivity of the cerebellar Crus II area, as a core component of social mentalizing in male perpetrators, and to explore if this connectivity is associated with social mentalizing processes. To achieve these objectives, we compared the resting-state connectivity of 25 men convicted for an IPVAW crime (male perpetrators) with 29 men convicted for other crimes (other offenders) and 28 men with no criminal records (non-offenders) using a seed-based whole brain analysis. Subsequently, correlations were performed to explore the association between the significant connectivity networks and social mentalizing measures only in male perpetrators of IPVAW. Analyses showed that male perpetrators of IPVAW exhibit hyperconnectivity between Crus II and posterior areas of the default mode network, frontoparietal and limbic areas compared to other offenders and non-offenders. In addition, the greater connectivity found between the Crus II and the posterior default mode network was related to a greater number of distorted thoughts about women and less affective empathy in male perpetrators of IPVAW. These results show that connectivity between the cerebellum and the default mode network may underlie the social processes that are at the basis of intimate partner violence perpetration.

Introduction

Social cognition includes mental operations concerning how we create representations of others and how these representations guide social actions, judgments and perceptions (Fiske and Taylor, 2020; Amodio, 2019). A key aspect of social cognitive functions is social mentalizing, the ability to understand the intentions, causes, emotions and beliefs of another person or the self (Baetens et al., 2014). This mind-to-mind process includes a range of meta-operations such as theory of mind, empathy, emotion recognition and self-reflective function (Adshead et al., 2013). Distortions in mentalizing could cause difficulties in both affective and social processing, and may lead to the emergence of antisocial behaviors such as violence (Möller et al., 2014).

Social mentalizing plays an undeniable role on intimate partner violence against women (IPVAW) perpetration (Misso et al., 2019). According to previous literature, male perpetrators of IPVAW present difficulties in emotional decoding, empathy and theory of mind (Romero-Martínez et al., 2013; Bueso-Izquierdo et al., 2015; Romero-Martínez et al., 2016). Moreover, it has been demonstrated that male perpetrators present irrational thoughts about women and the use of violence as an adaptive way of solving problems (for a more comprehensive review, see Ubillos-Landa et al., 2020). All these studies reveal

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the need for further research on social mentalizing in order to improve intervention programs for male perpetrators of IPVAW crime.

The underlying neurobiology contributing to social cognition in male perpetrators remains poorly understood. To date, only 5 studies have been published in this regard (Lee et al., 2008, 2009; Bueso-Izquierdo et al., 2016; Marín-Morales et al., 2021, 2022). Their results have shown different brain activation during emotion processing and moral dilemmas in male perpetrators of IPVAW in comparison to other offenders (men convicted for crimes other than IPVAW) and non-offenders (men with no criminal records). In the last decade, resting-state functional connectivity magnetic resonance imaging (rs-fMRI) has rapidly gained traction as a method of brain imaging (Leutgeb et al., 2016). Numerous rs-fMRI studies have identified altered connectivity between brain areas in violent populations (for a more comprehensive review, see Romero-Martínez et al., 2019). However, there is only one study that has explored the resting-state functional connectivity (rsFC) of male perpetrators, demonstrating that they present different rsFC between prefrontal, limbic and default mode network areas, and that this specific rsFC was associated with socioemotional processes (Amaoui et al. under review).

Neuroimaging studies that have attempted to study the process of social mentalizing agree that the key cerebral areas are the temporoparietal junction (TPJ) and the default mode network (DMN) (Li, 2014; Van Overwalle et al., 2015a), which encompasses the medial prefrontal cortex (MPFC), the posterior cingulum cortex (PCC), the middle temporal gyrus (mTG) and parietal areas including the precuneus and bilateral angular gyrus (AG) (Wang et al., 2020). However, a recent meta-analysis has shown the need to consider cerebro-cerebellar connections in such a complex process (Van Overwalle et al., 2015b). In fact, in the last decade, the number of studies focused on exploring the function of the cerebellum in social cognition has increased exponentially, highlighting the anatomical and functional connections between the cerebellum and the default mode network (Habas et al., 2009; Buckner et al., 2011; Yeo et al., 2011; Strata, 2015; Guell., 2018).

This novel literature proposes that the cerebellum modulates cortical activity by generating internal predictions based on the information it receives from the mentalizing regions and sending error signals if there is a mismatch between the predicted social events and actual behaviors (Van Overwalle et al., 2020a). Besides, novel studies have shown that there is an anatomical and functional specificity within the cerebellum, revealing that the Crus II area would show the higher implication on social mentalizing (Van Overwalle et al., 2020b) and presents a greater connectivity with the key cerebral areas (Van Overwalle and Mariën, 2016). In particular, numerous studies assessing processes requiring social mentalizing (Leggio and Olivito, 2018; Ma et al., 2021) have found greater activation of Crus II compared to other cerebro-cerebellar areas. Moreover, functional connectivity research showed that cerebellar Crus II area was specially related to executive network (Habas et al., 2009), and to DMN when social cognition processes are involved (Van Overwalle and Mariën, 2016).

In this study, we aimed to investigate the resting-state functional connectivity of the Crus II in male perpetrators of IPVAW in comparison to other offenders and non-offenders. In addition, we aimed to examine the association between the specific rsFC of the Crus II and social mentalizing processes found altered in male perpetrators. Based on a previous study of resting-state functional connectivity in male perpetrators (Amaoui et al., under review), we hypothesized that: (1) male perpetrators will present higher rsFC between Crus II seed and TPJ and DMN areas in comparison to other offenders and non-offenders; (2) The specific rsFC would be negatively associated with empathy and emotion decoding but positively associated with irrational thoughts about women and violence.

Materials and methods

Participants

Sample-size was estimated using the statistical tool G* Power (Faul et al., 2007). Based on a previous neuroimaging study of Bueso-Izquierdo et al. (2016) with an expected power of 0.8, an effect size of 0.9 and an alpha-level of 0.05, the resulting sample size had to be equal or higher to 25 participants per group. Finally, 84 participants were enrolled for this study: 26 men convicted for IPVAW crime (male perpatrators, MPG), 29 men convicted of crimes other than IPVAW crime (other offenders, OOG) and 29 men with no criminal records (non--offenders, NOG). Participants from both convicted groups were recruited from the Center for Social Insertion (CSI) in Granada (Spain). Non-offenders were recruited via advertisement, social networks and academies.

The inclusion criteria were: men aged 18 years or older. More specific criteria were set per study group. For male perpetrators group (MPG): being convicted of an intimate partner violence crime regulated by the Spanish law (de España, 2004, Law 1/2004, Comprehensive Protection Law against Intimate Partner Violence, IPV). This law covers any act of physical, psychological and sexual violence exercised over women by those who are or have been their male spouses or by those who are or have been linked to them by a similar relationship of affectivity, whether they are cohabiting or not. For other offenders group (OOG): being convicted for crimes other than intimate partner violence such as robbery, drug trafficking or traffic violation; and for the non-offenders group (NOG): not having any prior criminal record. Exclusion criteria for all participants were as follows: (a) illiteracy, (b) brain injury that has caused a loss of consciousness of more than 1 hour (Cohen et al., 2003), (c) antecedents of relevant psychological disorder, (d) history of drug or alcohol abuse (according to the Diagnostic and Statistical Manual of Mental Disorders 4th ed; DSM-IV) and (e) the presence of anomalies or contraindications to MRI scanning. Also, additional exclusion criteria for other offenders and non-offenders groups were added in order to control that none of the participants had a history of IPVAW. Based on previous studies (Bueso-Izquierdo et al., 2016; Marín-Morales et al., 2021, 2022), those men from the other offenders and non-offenders groups who obtained a score equal or greater to 11 on the severity subscale of the Conflict Tactic Scale-2 (Loinaz et al., 2012) were excluded. Specific information about demographic and crime characteristics of the sample are presented in Table 1.

Participants were invited to participate voluntarily and anonymously according to the Spanish legislation on personal data protection (Organic Law 3/2018, December 5). An informed consent was obtained from each participant prior to entering the study and they received 50 euros for participating in the study at the end of the evaluation. No penal benefit was obtained for the convicted groups. All examinations were approved by the Research Ethic Committee of the University of Granada in Spain (number issued: 1000/CEIH/2019).

Materials

The *Interview evaluating the risk of serious couple violence* (Echeburúa et al., 2008) was conducted to collect socio-demographic information about the perpetrator and the victim, type of violence (physical, psychological and sexual), information about the relationship status, the risk of serious couple violence, and vulnerability factors of the victim. Questions regarding head injury, medication use, childhood trauma (direct and indirect child violence experience) and substance dependence were added. Cronbach α values for the interview was .71.

The *Conflict Tactic Scale-2* (Spanish version, Loinaz et al., 2012) was used to assess the severity, frequency and intensity of the violence in the relationship. It also measures different conflict tactics used inside the relationship. The scale comprises 5 subscales (damages, negotiation,

Table 1
Sociodemographic and clinical information of MPG, NOG and OOG.

Variables (Mean (SD))	MPG (n = 25)	OOG (n = 29)	NOG (n = 28)	F/ $\chi2$	*p-value*
Sociodemographic information					
Age (years)	41.20 (9.91)	39.00 (11.05)	37.80 (8.02)	0.928	0.40
Years of education	9.00 (4.28)	9.55 (3.58)	9.79 (2.45)	0.324	0.72
Drug severity	1.11 (0.41)	1.09 (0.36)	0.91 (0.34)	2.58	0.08
Loss consciousness					
Yes (<30 min)	4% (1)	3.4% (1)	0% (0)	1.645	0.801
Yes (<15 min)	20% (5)	13.8% (4)	21.4% (6)		
No	76% (19)	82.8% (24)	78.6% (22)		
Prescribed medication					0.263
Yes	41,7% (10)	24,1% (7)	14,3% (4)		
No	12,5% (3)	13,8% (4)	14,35 (4)		
No medication	45,8% (11)	62,1% (18)	71,4% (20)		
Direct violence during childhood				1.675	0.433
Yes	12% (3)	24.1% (7)	25% (7)		
No	88% (22)	75.9% (22)	75% (21)		
Indirect violence during childhood				1.389	0.499
Yes	20% (5)	20.7% (6)	32.1% (9)		
No	80% (20)	79.3% (23)	67.9% (19)		
Crime characterization					
CTS-2					
Severity of violence	4.32 (6.39)	0.24 (0.51)	0.32 (0.95)	5.02*	<0.01
Physical aggression	2.00 (2.02)	0.24 (0.51)	0.32 (0.94)		
Psychological aggression	3.52 (2.28)	1.55 (1.62)	1.32 (1.52)		
Sexual Coercion	0.68 (1.22)	0.7 (0.26)	0.14 (0.36)		
Injury	0.88 (1.51)	0.21 (0.77)	0.11 (0.42)		
Negotiation	4.16 (1.67)	4.41 (1.57)	4.96 (1.37)		
Type of crime					
	PV = 56% (14) PPV = 44% (11)	SCF = 10.3% (3) DD = 17.24% (5) UM = 10.3% (3) GAR = 24.26% (7) DT = 34.5% (10) VF = 3.4% (1)		2.619	0.106
Social mentalizing measures					
IPDMV					
IPDV	2.92 (2.18)	3.76 (2.82)	1.75 (1.29)	5.976*	0.002
IPDM	3.84 (3.41)	4.69 (2.97)	2.93 (2.00)	2.755	0.065
IRI					
Cognitive empathy	36.56 (6.63)	42.00 (6.15)	43.75 (7.68)	7.817*	<0.01
Affective empathy	37.24 (6.83)	40.34 (5.03)	38.71 (5.00)	2.053	0.164
Eyes' Test					
Emotion recognition[a]	19.33 (4.78)	19.40 (4.36)	20.56 (4.41)	0.695	0.061

Measures of loss consciousness, violence during childhood and type of crime on (% [n]). MPG = male perpetrators group; OOG = other offenders group; NOG = non-offenders group; CTS-2 = Conflict Tactic Scale-2; Drug severity variable (log10 normalized); PV = psychological violence; PPV = physical and psychological violence; SCF = scams or crimes of forgery; DD = dangerous driving; GAR = Grave assault/robbery; DT = drug trafficking; VF = violent fight; UM = unspecified misdemeanor (lost answers). IPDV = Inventory of distorted thoughts about the use of violence; IPDM = Inventory of distorted thoughts about women; Cognitive empathy = composed of perspective taking and fantasy subscales of the IRI; affective empathy = composed of empathic concern and personal distress subscales of the IRI; Emotion recognition = measured using the Eyes' test.
[a] Lost answers. MPG (N = 15), OOG (N = 15), NOG (N = 16).

physical violence, sexual coercion and psychological aggression) and two levels of severity (minor or severe). It uses an 8-point Likert scale ranged from 0 “this has never happened” to 6 “more than 20 times in the past year”, and 7 means “not in the past year, but it did happen before”. Cronbach α values for the CTS-2 ranged from 0.34 to 0.94.

The *Inventory of Distorted Thoughts about Women and Violence* (IPDMV; Echeburúa & Fernández-Montalvo, 1997) is a self-report inventory to measure irrational thoughts. The inventory is divided in two subscales: 13 items related to irrational thought about sexual roles and inferiority of women (IPDM) and 16 items related to the use of violence as a correct method of conflict resolution (IPDV). Cronbach α values were 0.662 and 0.519 respectively.

The *Interpersonal Reactivity Index* (IRI) by Pérez-Albéniz et al. (2003) was conducted to assess empathy as a self-report measure. Two subscales were used in this study: cognitive empathy (composed of perspective taking and fantasy subscales) and affective empathy (composed of empathic concern and personal distress subscales), with a Cronbach α ranging from 0.56 to 0.70.

The *Eyes Test* of Fernández-Abascal et al. (2013) is a conductual task used to evaluate the ability to recognize complex mental states expressed by human eyes. It consists of 36 photographs of eyes and in each item participants are instructed to choose among four descriptors based on what they think the person in the photography is feeling. Each item is scored as correct or incorrect. Consequently, the higher the score, the greater is the ability to recognize emotions. This task present a test-retest value of 0.63.

MRI data acquisition and preprocessing

Anatomical and resting-state functional MRI were acquired with a 3-T scanner (Siemens TRIO) at the Mind, Brain and Behavior Research Center of the University of Granada (Spain). High spatial resolution T1-weighted anatomic images were acquired in the sagittal orientation using a three-dimensional weighted turbo-gradient-echo sequence (repetition time (TR) = 2300 ms; Echo time (TE) = 3.1 ms, Field of view (FOV) = 208; Voxel size = 0.8 × 0.8 × 0.8 mm, Number of slices = 208) in order to check for any gross anatomical abnormality. Functional MRI data were acquired during a resting-state scan. Participants were instructed to lie still with their eyes close without falling asleep during 8 min. Functional images were acquired using a T2*-weighted echo-planar imaging (EPI) sequence through the following parameters: TR = 2.0s; TE = 25 ms; FOV = 238 × 238 mm; Acquisition Matrix = 68 × 68; thirty-five 3.5 m axial slices, Voxel Size = 3.5 × 3.5 × 3.5 mm, 240 whole-brain volumes.

Functional images were preprocessed using the Functional Connectivity CONNv17 Toolbox (Whitfield-Gabrieli and Nieto-Castanon, 2012) running under Matlab R2017a (MatchWorks, Natick, MA, USA). Briefly, the preprocessing included the following steps: (a) realignment and slice-timing correction, (b) denoising and outlier detection (c) segmentation, (d) co-registration of each participant's anatomical scan to functional images, (e) normalization, (f) reslice to a 2 mm voxel size in MNI space, (g) smoothing of functional images with a 6-mm FWHM isotropic Gaussian Kernel, (h) temporal band-pass filtering (0.008–0.09 Hz) and linear detrending term. Two subjects, one from the MPG group and one from the NOG group, were excluded because cerebellar images could not be acquired.

Seed definition and functional connectivity analysis

To assess functional connectivity of the Crus II, we performed a seed-based functional connectivity analysis using the functional connectivity CONNv17 Toolbox (Whitfield-Gabrieli and Nieto-Castanon, 2012). Seeds of interest were determined based on the meta-analysis of Van Overwalle et al. (2015). Coordinates from the meta-analysis were transformed to the MNI stereotaxic space. Then, to avoid overlap between seeds, those located less than 8 mm apart were identified and replaced by a new region of interest in the centroid of these seeds. Therefore, from the original 24 seeds, we lasted with 16 seeds. Finally, only those that were localized in Crus II were selected.

In total, 2 Crus II seeds were defined in each cerebellar hemisphere using a 5-mm radius sphere: left posterior Crus II ($x = -13$, $y = -80$, $z = -42$), left lateral Crus II ($x = -25$, $y = -82$, $z = -38$); right posterior Crus II ($x = 10$, $y = -79$, $z = -43$) and right lateral Crus II ($x = 24$, $y = -82$, $z = -36$) using the Marsbar Toolbox for SPM12 in MNI stereotaxic space.

Subject specific first-level general linear models (GLM) were defined including the mean activity courses of each seed extracted from the MarsBaR toolbox (http://marsbar.sourceforge.net) and nuisance signals as regressors of no interest. Nuisance signals included motion, white matter and cerebrospinal fluid time series. A high-pass filter (128 s) was used to eliminate low-frequency noise. Images were created for each subject by calculating the regression coefficient between all brain voxels and each seed's time series.

In order to investigate group differences in each seed's connectivity, first-level contrast images were included in a separate second-level one-way ANOVA model. Drug severity and age were included as covariates. The imaging results were corrected for multiple comparisons using Monte Carlo simulations using AlphaSim implemented in the REST-plusV1.2 Toolbox. For between-group comparisons, Alphasim input parameters included a whole brain mask (242 545 voxels; $2 \times 2 \times 2$ mm), a cluster connection radius of 5 mm, and results were significant at an α value of 0.025 and an individual voxel threshold probability of $p < .001$. The resulting minimum cluster size was different for each seed; for left posterior Crus II was 103 voxels (824 mm^3), for left lateral Crus II was 93 voxels (744 mm^3), for right posterior Crus II was 95 voxels (760 mm^3) and for right lateral Crus II was 97 voxels (776 mm^3).

Statistical analyses

Demographic and behavioral data were analyzed using Jamovi (Version 1.6, The jamovi project, 2021). ANOVA tests were conducted to assess differences between groups. Only group differences were found in drug consumption, therefore, a variable of drug severity was created by the sum of the criteria of the DSM-IV for alcohol and drugs, including frequency and intensity of the consumption. Then, this variable was normalized and used as a confounding variable in all analyses.

Additionally, we tested if the specific rsFC of the Crus II in male perpetrators correlated with social mentalizing measures. For this purpose, the database was imputed (5.8% missing values) using the algorithm of the missforest package (Stekhoven and Bühlmann, 2012). Then, Spearman partial correlations were conducted between the extracted values of each rsFC and the behavioral measures (distorted thoughts about women and the use of violence, cognitive empathy, affective empathy and emotion recognition) controlling for age and drug severity. The correlational analyses were considered significant at a threshold at $p < .05$. Finally, Fisher r-to-z transformation was performed to calculate between-group interactions in these correlations.

Results

Demographic data and crime characteristics

Groups did not differ in age, education level, type of crimes and child violence experience. Differences were found in the severity subscale of the Conflict Tactic Scale (CTS-2), where male perpetrators showed significantly higher scores in comparison to other offenders and non-offenders (Table 1).

Between-group differences in functional connectivity

Based on the main objective of the study, the results were organized by comparing the group of male perpetrators with each of the other two groups.

Male perpetrators group (MPG) > non-offenders group (NOG). MPG showed higher functional connectivity between left posterior Crus II and left parahippocampus/hippocampus. Moreover, MPG showed higher functional connectivity between right posterior Crus II and right precuneus, right angular gyrus (AG), left posterior cingulum cortex and bilateral parahippocampal. Finally, male perpetrators demonstrated also higher functional connectivity between right lateral Crus II and mid-temporal gyrus (mTG). There were no group differences in left lateral Crus II functional connectivity. NOG did not demonstrate higher functional connectivity than MPG in any of the seeds (Table 2 and Fig. 1).

Male perpetrators (MPG) > other offenders group (OOG). MPG demonstrated higher functional connectivity between left posterior Crus II and bilateral intraparietal sulcus (IPS), left precuneus/parietal superior area and left frontal inferior operculum in comparison to OOG. Moreover, MPG showed higher functional connectivity between right posterior Crus II and cuneus, right mid-occipital area, right fusiform gyrus and left parahippocampal. Finally, MPG demonstrated higher functional connectivity than the non-offenders group between right lateral Crus II and cuneus. Again, there were no differences in left lateral Crus II functional connectivity. OOG did not demonstrate higher functional connectivity than MPG in any of the selected seeds (Table 2 and Fig. 1).

Comparisons between other offenders (OOG) and non-offenders (NOG) are described in the Supplementary material 1.

Correlations with social mentalizing variables in male perpetrators

Functional connectivity between right posterior Crus II and precuneus was found positively correlated with irrational thoughts about women only in male perpetrators ($r = 0.430$, $p = .041$). This correlation was found inverse in non-offenders ($r = -0.480$, $p = .013$). The comparison between these correlations showed a significant difference (z score $= 3.43$, $p < .001$). This correlation was not found significant in the other offenders group.

Functional connectivity between right lateral Crus II and mid-temporal gyrus was negatively correlated with affective empathy in male perpetrators ($r = -0.458$, $p = .028$). This correlation was not found significant in any of the other two groups. Direct comparison between these correlations (MPG vs NOG) revealed a significant difference (z score $= -2.05$, $p < .05$) (see Fig. 2). Specific information about the scores in all scales are presented in Table 1.

Discussion

The goal of this study was to investigate Crus II resting-state functional connectivity in male perpetrators in comparison to non-offenders and other offenders, and how it relates to social mentalizing processes. We observed hyperconnectivity of the Crus II with parahippocampal/hippocampus,default mode network, intraparietal sulcus and occipital areas in male perpetrators. We also found that the specific resting-state

Table 2
Significant differences between male perpetrators (MPG), non-offenders (NOG), and other offenders (OOG) in functional connectivity.

Seed	Brain Region	x	y	z	*ke*	Peak *t* value
MPG > NOG						
L posterior Crus II	Parahippocampal/hippocampus	−22	−34	−10	136	4.46
R posterior Crus II	Precuneus	20	−64	24	248	4.32
	Angular gyrus	42	−50	32	240	4.33
	Parahippocampal	−18	−36	−8	217	5.58
	Posterior cingulum	−8	−44	20	151	4.78
	Parahippocampal	18	−36	−16	113	4.39
R lateral Crus II	Mid-temporal gyrus	−60	−14	−14	126	4.60
MPG > OOG						
L posterior Crus II	Intraparietal sulcus	−26	−62	42	296	4.49
	Intraparietal sulcus	22	−60	48	269	4.60
	Precuneus/parietal superior	−18	−74	52	161	4.46
	Frontal inferior gyrus	−36	14	28	150	4.29
R posterior Crus II	Cuneus	−4	−82	20	1152	4.66
	Mid occipital	42	−76	6	393	4.72
	Parahippocampal	−22	−28	−16	260	4.58
	Fusiform gyrus	36	−48	−12	192	4.64
R lateral Crus II	Cuneus	−4	−86	18	841	5.06

Coordinates (x, y, z) are given in Montreal Neurological Institute atlas space (MNI). ke = cluster size in voxels.

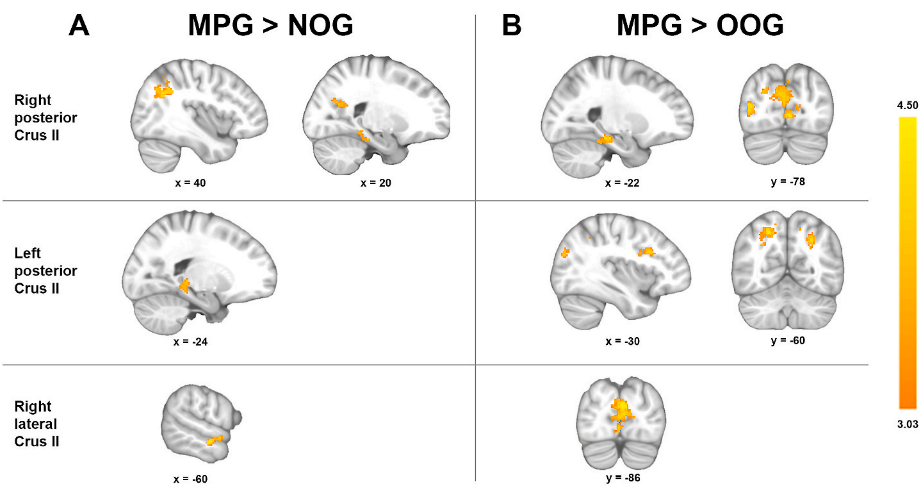

Fig. 1. Significant group differences in Crus II seed-based analysis. Each brain image represents the correlation of the seed written below. MPG = male perpetrators group; NOG = non-offenders group; OOG = other offenders group.
Note. Each brain image represents the correlation of the seed written below. MPG = male perpetrators group; OOG = other offenders group NOG = non-offenders group **A.** MPG demonstrated higher functional connectivity than NOG between left posterior Crus II and parahippocampal/hippocampus, between right lateral Crus II and precuneus, angular gyrus, posterior cingulum and parahippocampal, and between right posterior Crus II and mid-temporal gyrus **B.** MPG demonstrated higher functional connectivity than OOG between left posterior Crus II and bilateral intraparietal sulcus, precuneus/parietal superior and frontal inferior gyrus, between right posterior Crus II and cuneus, mid-occipital area, parahippocampal and fusiform gyrus, and between right lateral Crus II and cuneus and mid-temporal gyrus.

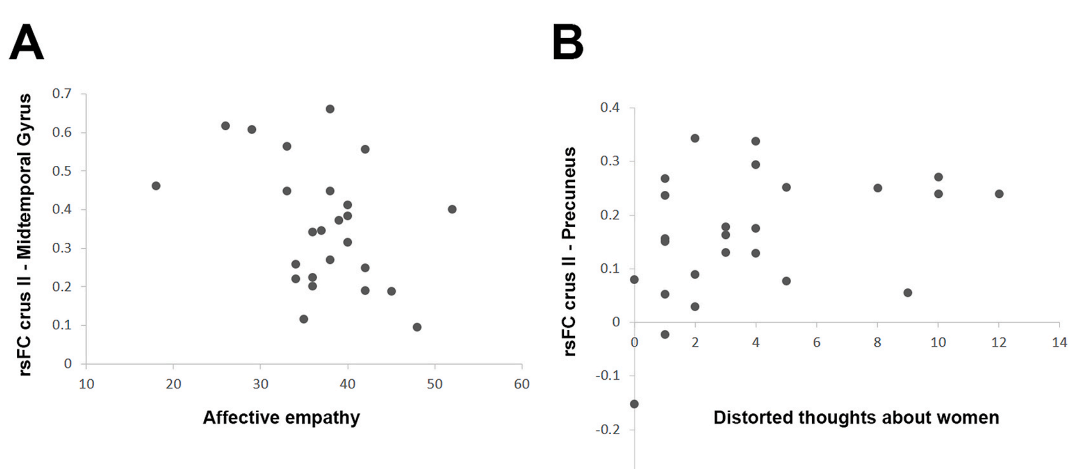

Fig. 2. Significant Spearman partial correlations between resting-state functional connectivity and social mentalizing processes in male perpetrators.
Note. Age and drug severity as control variables. MPG = male perpetrators group. A. Negative correlation between resting-state functional connectivity Crus II – mid temporal gyrus and affective empathy. B. Positive correlation between the resting-state functional connectivity Crus II – precuneus and distorted thoughts about women.

functional connectivity in male perpetrators was associated with irrational thoughts about women and with affective empathy.

Our principal connectivity hypothesis was supported by these results, demonstrating that male perpetrators presented higher resting-state functional connectivity between Crus II and posterior areas of the default mode network in comparison to non-offenders. More concretely, perpetrators showed higher resting-state functional connectivity of the right posterior Crus II seed with the middle temporal gyrus, precuneus, right angular gyrus and left posterior cingulate cortex. This interaction or connectivity and its clinical implications have been widely evidenced (Schmahmann, 2004), and most of the findings converge on the assumption that hypoconnectivity would result in deficits in social mentalizing (Shinn et al., 2015). However, less recognition has been given to the study of cerebellum in non-clinical research and more specifically in forensic research (Demirtas-Tatlidede and Schamahmann, 2013). Only few studies have shown that violent populations exhibit altered resting-state functional connectivity between the cerebellum and the default mode network (DMN) in relation to violent proneness (for a more comprehensive review, see Romero-Martínez et al., 2019). Furthermore, in a meta-analysis by Klaus and Schutter (2021) it has been demonstrated that the posterior cerebellum (Crus I and Crus II) is co-activated together with the default mode network during fear and anger processing. We therefore, suggest that higher functional connectivity between the Crus II and the default mode network might be related with difficulties in emotional processing in male perpetrators.

Interestingly, the connectivity in this network did not remain significant when comparing male perpetrators and other offenders. Despite this, perpetrators showed a higher resting-state functional connectivity between right posterior Crus II and bilateral intraparietal sulcus and inferior frontal operculum. These cerebral areas are key regions within the brain networks that monitor executive functions, cognitive control and motor control processes (Hampshire et al., 2010; Bray et al., 2015). Significantly, several studies support the role of the cerebellum in these networks. Indeed, during cognitive tasks (executive functions, working memory and attentional processes), the activation of the cerebellum comes along with the activation of prefrontal and parietal regions (Stoodley, 2012; Leggio and Olivito, 2018; Skouras et al., 2018). The proposed function of the cerebellum in these cognitive processes would consist in detecting errors between the predicted output and the current behavior, and sending back this information to brain areas in order to generate adaptive behavior (Leggio and Olivito, 2018). These results may indicate that the difference in resting-state functional connectivity between other offenders and specific male perpetrators may be located in a more cognitive domain.

Also, male perpetrators showed greater connectivity between Crus II and the parahippocampus/hippocampus in comparison to other offenders and non-offenders. The posterior cerebellum has various anatomical and functional connections with cerebral regions involved in high-level mental processes like emotion regulation (Snow., 2014), empathy (Lang et al., 2011), moral judgment and violence (Demirtas-Tatlidede and Schmahmann, 2013). These regions include the limbic system, and more concretely the amygdala and hippocampus (Strick et al., 2009). The higher connectivity found between Crus II, parahippocampus and hippocampus in male perpetrators might be related to difficulties in processing moral emotions (Leutgeb et al., 2016).

These neuroimaging results can be further understood by looking at the correlational results. In fact, it has been found that the higher the resting-state connectivity between the cerebellar Crus II area and posterior default mode network (specifically, precuneus and mid-temporal gyrus), the greater the number of distorted thoughts about women and the lower the empathy. Literature has shown that the resting-state connectivity between these areas may be a reliable marker of specific cognitive abilities and personality traits that are related to behavior regulation, and more specifically to violent proneness (Romero-Martínez et al., 2019). These correlations allow us to propose that there is a specific relationship between resting-state connectivity of Crus-II with posterior areas of the DMN and disturbances in social cognition processes that may promote IPVAW perpetration (Ubillos-Landa et al., 2020; Romero-Martínez et al., 2016).

There are several limitations to the present study. First, the nature of male perpetrators is very diverse, consequently, in this study we were unable to take into account other relevant variables such as personality characteristics, or other sociocultural variables. Therefore, we propose the need to carry out future studies where these variables could be under consideration. Second, some of the social mentalizing measures are not specific to intimate partner violence and even if significant results have been found, previous literature proposes that the brain activation of male perpetrators is strongly related to intimate partner violence stimuli (Marín-Morales et al., 2021). Third, although seed analysis is one of the most used techniques in the violent population, it is a tool that depends on prior seed selection, which makes results interpretable (Lv et al., 2018).

Despite the above limitations, this is the second study to explore the resting-state brain mechanisms underlying social cognition processes in men convicted of intimate partner violence. The value of studying intrinsic connectivity in violent populations has been widely defended in the literature, not only because it is a neuroimaging tool that allows us to understand how the brain processes social information (Doruyter et al., 2017), but also as a possible marker of violent proneness (Romero-Martínez et al., 2019). Alterations in the process of social mentalizing could lead to a spiral of behavior that is not only maladaptive, but violent towards other people (Möller et al., 2014). In this study it has been found again that male perpetrators show hyperconnectivity compared to men with no criminal records and men convicted of other crimes.

The most extended research line argues that cerebro-cerebellar hypoconnectivity could underlie alterations in different social cognition processes in people with clinical diagnoses (Shinn et al., 2015). Although studies with non-clinical populations are scarcer, one would expect to find the same results. However, what we found in male perpetrators is a hyperconnectivity accompanied by significant associations with measures of social mentalizing. One possible explanation is the existence of compensatory mechanisms. This proposal has been taken in violent populations (Leutgeb et al., 2016) and psychopathic criminals (Contreras-Rodríguez et al., 2014). This mechanism would suggest the need of an effort to compensate for deficient coupling between brain areas involved in socioemotional processing (Leutgeb et al., 2016). This is a novel proposal that would require future studies in order to validate it.

We conclude that the cerebellum is a core structure for social cognition processes. More concretely, in this study we found that resting-state functional connectivity between Crus II and default mode network, limbic areas and prefrontal areas is specific of male perpetrators and it is related to social mentalizing processes associated with violent perpetration. Although in this study we focus on Crus II as a specialized area in social mentalizing process (VanOverwalle et al., 2020), future studies are needed in order to explore the cerebellar functioning of anterior (IV, V and VI) and posterior (Crus I and lobule IX) areas in male perpetrators as a modulator of social processes. Finally, we highlight the great importance of including the work on the different processes of social cognition in intervention programs with male perpetrators and in prevention programs.

Credit author statement

Sofia Amaoui: Investigation, formal analyses, data curation, writing-original draft, visualization.

Agar Marín-Morales: Conceptualization, methodology, investigation, writing-review & editing.

Cristina Martín-Pérez: Data curation, writing-Review & editing, supervision.

Miguel Pérez-García: Conceptualization, methodology, resources, writing-Review & editing, supervision, project administration.

Juan Verdejo-Román: Conceptualization, software, methodology, data curation, supervision, writing-Review & editing.

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Declaration of competing interest

The authors declare that have no conflict of interest in this study.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychires.2022.03.044.

References

Adshead, G., Moore, E., Humphrey, M., Wilson, C., Tapp, J., 2013. The role of mentalising in the management of violence. Adv. Psychiatr. Treat. 19, 67–76. https://doi.org/10.1192/apt.bp.110.008243.

Amaoui, S., Marín-Morales, A., Martin-Pérez, C., Pérez-García, M., Verdejo-Román, J., 2021. Cerebellar connectivity in male perpetrators is associated with irrational thoughts about women. In: Presented in the Organization for Human Brain Mapping Congress (Online. Published).

Amodio, D.M., 2019. Social cognition 2.0: an interactive memory systems account. Trends Cognit. Sci. 23, 21–33. https://doi.org/10.1016/j.tics.2018.10.002.

Baetens, K., Ma, N., Steen, J., Van Overwalle, F., 2014. Involvement of the mentalizing network in social and non-social high construal. Soc. Cognit. Affect Neurosci. 9, 817–824. https://doi.org/10.1093/scan/nst048.

Bray, S., Almas, R., Arnold, A.E.G.F., Iaria, G., MacQueen, G., 2015. Intraparietal sulcus activity and functional connectivity supporting spatial working memory manipulation. Cerebr. Cortex 25, 1252–1264. https://doi.org/10.1093/cercor/bht320.

Buckner, R.L., Krienen, F.M., Castellanos, A., Diaz, J.C., Yeo, B.T.T., 2011. The organization of the human cerebellum estimated by intrinsic functional connectivity. J. Neurophysiol. 106, 2322–2345. https://doi.org/10.1152/jn.00339.2011.

Bueso-Izquierdo, N., Hidalgo-Ruzzante, N., Burneo-Garcés, C., Pérez-García, M., 2015. Procesamiento emocional en maltratadores de género mediante el Test de Expresiones Faciales de Ekman y la Tarea Stroop Emocional. [Emotional processing in perpetrators as assessed by Test Ekman Facial Expressions and Emotional Stroop Task in intimate partner violence situations. Rev. Latinoam. Psicol. 47, 102–110. https://doi.org/10.1016/j.rlp.2015.02.001.

Bueso-Izquierdo, N., Verdejo-Román, J., Contreras-Rodríguez, O., Carmona-Perera, M., Pérez-García, M., Hidalgo-Ruzzante, N., 2016. Are perpetrators different from other criminals? An fMRI study. Soc. Cognit. Affect Neurosci. 11, 852–862. https://doi.org/10.1093/scan/nsw020.

Cohen, R.A., Brumm, V., Zawacki, T.M., Paul, R., Sweet, L., Rosenbaum, A., 2003. Impulsivity and verbal deficits associated with domestic violence. J. Int. Neuropsychol. Soc. 9, 760–770.

Contreras-Rodríguez, O., Pujol, J., Batalla, I., Harrison, B.J., Bosque, J., Ibern-Regàs, I., Hernández-Ribas, R., Soriano-Mas, C., Deus, J., López-Solà, M., Pifarré, J., Menchón, J.M., Cardoner, N., 2014. Disrupted neural processing of emotional faces in psychopathy. Soc. Cognit. Affect Neurosci. 9, 505–512. https://doi.org/10.1093/scan/nst014.

de España, G., 2004. Ley Orgánica 1/2004, de 28 de diciembre, de Medidas de Protección Integral contra la Violencia de Género.

Demirtas-Tatlidede, A., Schmahmann, J.D., 2013. Morality: incomplete without the cerebellum? Brain. J. Neurol. 136, 244. https://doi.org/10.1093/brain/awt070.

Doruyter, A., Groenewold, N.A., Dupont, P., Stein, D.J., Warwick, J.M., 2017. Resting-state fMRI and social cognition: an opportunity to connect. Hum. Psychopharmacol. Clin. Exp. 32, 2627. https://doi.org/10.1002/hup.2627.

Echeburúa, J.F.-M., Corral, P., 2008. ¿Hay diferencias entre la violencia grave y la violencia menos grave contra la pareja?: un análisis comparativo. Int. J. Clin. Health Psychol. 8, 355–382. E.

Faul, F., Erdfelder, E., Lang, A.-G., Buchner, A., 2007. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav. Res. Methods 39, 175–191. https://doi.org/10.3758/BF03193146.

Fernández-Abascal, E.G., Cabello, R., Fernández-Berrocal, P., Baron-Cohen, S., 2013. Test-retest reliability of the 'Reading the Mind in the Eyes' test: a one-year follow-up study. Mol. Autism. 4, 1–6. https://doi.org/10.1186/2040-2392-4-33.

Fiske, S.T., Taylor, S.E., 2020. Social cognition evolves: illustrations from our work on intergroup bias and on healthy adaptation. Psicothema 32, 291–297. https://doi.org/10.7334/psicothema2020.197.

Guell, X., Gabrieli, J.D.E., Schmahmann, J.D., 2018. Triple representation of language, working memory, social and emotion processing in the cerebellum: convergent evidence from task and seed-based resting-state fMRI analyses in a single large cohort. Neuroimage 172, 437–449. https://doi.org/10.1016/j.neuroimage.2018.01.082.

Habas, C., Kamdar, N., Nguyen, D., Prater, K., Beckmann, C.F., Menon, V., Greicius, M. D., 2009. Distinct cerebellar contributions to intrinsic connectivity networks. J. Neurosci.: Off. J. Soc. Neurosci. 29, 8586–8594. https://doi.org/10.1523/JNEUROSCI.1868-09.2009.

Hampshire, A., Chamberlain, S.R., Monti, M.M., Duncan, J., Owen, A.M., 2010. The role of the right inferior frontal gyrus: inhibition and attentional control. Neuroimage 50, 1313–1319. https://doi.org/10.1016/j.neuroimage.2009.12.109.

Klaus, J., Schutter, D.J.L.G., 2021. Functional topography of anger and aggression in the human cerebellum. Neuroimage 226, 117582. https://doi.org/10.1016/j.neuroimage.2020.117582.

Lang, S., Yu, T., Markl, A., Müller, F., Kotchoubey, B., 2011. Hearing others' pain: neural activity related to empathy. Cognit. Affect Behav. Neurosci. 11, 386–395. https://doi.org/10.3758/s13415-011-0035-0.

Lee, T.M.C., Chan, S.C., Raine, A., 2008. Strong limbic and weak frontal activation to aggressive stimuli in spouse abusers. Mol. Psychiatr. 13, 655–656. https://doi.org/10.1038/mp.2008.46.

Lee, T., Chan, S.-C., Raine, A., 2009. Hyperresponsivity to threat stimuli in domestic violence offenders. J. Clin. Psychiatr. 70, 36–45. https://doi.org/10.4088/JCP.08m04143.

Leggio, M., Olivito, G., 2018. Topography of the cerebellum in relation to social brain regions and emotions. Handb. Clin. Neurol. 154, 71–84. https://doi.org/10.1016/B978-0-444-63956-1.00005-9.

Leutgeb, V., Wabnegger, A., Leitner, M., Zussner, T., Scharmüller, W., Klug, D., Schienle, A., 2016. Altered cerebellar-amygdala connectivity in violent offenders: a resting-state fMRI study. Neurosci. Lett. 610, 160–164. https://doi.org/10.1016/j.neulet.2015.10.063.

Li, W., Mai, X., Liu, C., 2014. The default mode network and social understanding of others: what do brain connectivity studies tell us. In: Frontiers in Human Neuroscience 0. https://doi.org/10.3389/fnhum.2014.00074.

Loinaz, I., Echeburúa, E., Ortiz-Tallo, M., Amor, P.J., 2012. Propiedades psicométricas de la Conflict Tactics Scales (CTS-2) en una muestra española de agresores de pareja. Psicothema 24, 142–148.

Lv, H., Wang, Z., Tong, E., Williams, L.M., Zaharchuk, G., Zeineh, M., Goldstein-Piekarski, A.N., Ball, T.M., Liao, C., Wintermark, M., 2018. Resting-state functional MRI: everything that nonexperts have always wanted to know. AJNR. Am. J. Neuroradiol. 39, 1390–1399. https://doi.org/10.3174/ajnr.A5527.

Ma, Q., Pu, M., Haihambo, N.P., Baetens, K., Heleven, E., Deroost, N., et al., 2021. The posterior cerebellum and temporoparietal junction support explicit learning of social belief sequences. Cognit. Affect Behav. Neurosci. 1–25. https://doi.org/10.3758/s13415-021-00966-x.

Marín-Morales, A., Bueso-Izquierdo, N., Hidalgo-Ruzzante, N., Pérez-García, M., Catena-Martínez, A., Verdejo-Román, J., 2022. Would you allow your wife to dress in a miniskirt to the party"? Batterers do not activate default mode network during moral decisions about intimate partner violence. J. Interpers Violence. https://doi.org/10.1177/0886260520926494, 37(3-4), NP1463-NP1488.

Marín-Morales, A., Pérez-García, M., Catena-Martínez, A., Verdejo-Román, J., 2021. Emotional regulation in male perpetrators when faced with pictures of intimate partner violence. Do they have a problem with suppressing or experiencing emotions? J. Interpers Violence. https://doi.org/10.1177/0886260520985484, 0886260520985484.

Misso, D., Schweitzer, R.D., Dimaggio, G., 2019. Metacognition: a potential mechanism of change in the psychotherapy of perpetrators of domestic violence. J. Psychother. Integrat. 29, 248. https://doi.org/10.1037/int0000111.

Möller, C., Falkenström, F., Holmqvist Larsson, M., Holmqvist, R., 2014. Mentalizing in young offenders. Psychoanal. Psychol. 31, 84–99. https://doi.org/10.1037/a0035555.
Overwalle, F.V., D'aes, T., Mariën, P., 2015. Social cognition and the cerebellum: a meta-analytic connectivity analysis. Hum. Brain Mapp. 36, 5137–5154. https://doi.org/10.1002/hbm.23002.
Pérez-Albéniz, A., De Paúl, J., Etxeberría, J., Montes, M.P., Torres, E., 2003. Adaptación de interpersonal reactivity index (IRI) al español. Psicothema 267–272.
Romero-Martínez, Á., Lila, M., Catalá-Miñana, A., Williams, R.K., Moya-Albiol, L., 2013. The contribution of childhood parental rejection and early androgen exposure to impairments in socio-cognitive skills in intimate partner violence perpetrators with high alcohol consumption. Int. J. Environ. Res. Publ. Health 10, 3753–3770. https://doi.org/10.3390/ijerph10083753.
Romero-Martínez, Á., Lila, M., Moya-Albiol, L., 2016. Empathy impairments in intimate partner violence perpetrators with antisocial and borderline traits: a key factor in the risk of recidivism. Violence Vict. 31, 347–360. https://doi.org/10.1891/0886-6708.VV-D-14-00149.
Romero-Martínez, Á., González, M., Lila, M., Gracia, E., Martí-Bonmatí, L., Alberich Bayarri, A., Maldonado-Puig, R., Ten-Esteve, A., Moya-Albiol, L., 2019. The brain resting-state functional connectivity underlying violence proneness: is it a reliable marker for neurocriminology? A systematic review. https://doi.org/10.3390/bs9010011.
Schmahmann, J.D., 2004. Disorders of the cerebellum: ataxia, dysmetria of thought, and the cerebellar cognitive affective syndrome. J. Neuropsychiatry Clin. Neurosci. 16, 367–378. https://doi.org/10.1176/jnp.16.3.367.
Shinn, A.K., Baker, J.T., Lewandowski, K.E., Öngür, D., Cohen, B.M., 2015. Aberrant cerebellar connectivity in motor and association networks in schizophrenia. Front. Hum. Neurosci. 9, 134. https://doi.org/10.3389/fnhum.2015.00134.
Skouras, S., Gispert, J.D., Molinuevo, J.L., 2018. The Crus exhibits stronger functional connectivity with executive network nodes than with the default mode network. Brain: J. Neurol. 141, 24. https://doi.org/10.1093/brain/awy025.
Snow, W.M., Stoesz, B.M., Anderson, J.E., Snow, W.M., Stoesz, B.M., Anderson, J.E., 2014. The cerebellum in emotional processing: evidence from human and non-human animals. AIMS Neurosci. 1, 96–119. https://doi.org/10.3934/Neuroscience.2014.1.96.
Stekhoven, D.J., Bühlmann, P., 2012. MissForest—non-parametric missing value imputation for mixed-type data. https://doi.org/10.1093/bioinformatics/btr597.
Stoodley, C.J., 2012. The cerebellum and cognition: evidence from functional imaging studies. https://doi.org/10.1007/s12311-011-0260-7.
Strata, P., 2015. The emotional cerebellum. https://doi.org/10.1007/s12311-015-0649-9.
Strick, P.L., Dum, R.P., Fiez, J.A., 2009. Cerebellum and nonmotor function. Annu. Rev. Neurosci. 32, 413–434. https://doi.org/10.1146/annurev.neuro.31.060407.125606.
Ubillos-Landa, S., Puente-Martínez, A., González-Castro, J.L., Nieto-González, S., Muñoz Rujas, N.A.U., Aguilar Romero, F.A.U., 2020. You belong to me! Meta-analytic review of the use of male control and dominance against women in intimate partner violence. Aggress. Violent Behav. 52, 101392. https://doi.org/10.1016/j.avb.2020.101392.
Van Overwalle, F., Mariën, P., 2016. Functional connectivity between the cerebrum and cerebellum in social cognition: a multi-study analysis. Neuroimage 124, 248–255. https://doi.org/10.1016/j.neuroimage.2015.09.001.
Van Overwalle, F., Baetens, K., Mariën, P., Vandekerckhove, M., 2015. Cerebellar areas dedicated to social cognition? A comparison of meta-analytic and connectivity results. Soc. Neurosci. 10, 337–344. https://doi.org/10.1080/17470919.2015.1005666.
Van Overwalle, F., Ma, Q., Heleven, E., 2020a. The posterior Crus II cerebellum is specialized for social mentalizing and emotional self-experiences: a meta-analysis. Soc. Cognit. Affect Neurosci. 15 https://doi.org/10.1093/scan/nsaa124.
Van Overwalle, F., Manto, M., Cattaneo, Z., Clausi, S., Ferrari, C., Gabrieli, J.D.E., Guell, X., Heleven, E., Lupo, M., Ma, Q., Michelutti, M., Olivito, G., Pu, M., Rice, L.C., Schmahmann, J.D., Siciliano, L., Sokolov, A.A., Stoodley, C.J., Dun, K., Leggio, M., 2020b. Consensus paper: cerebellum and social cognition. Cerebellum 19, 833–868. https://doi.org/10.1007/s12311-020-01155-1.
Wang, S., Tepfer, L.J., Taren, A.A., Smith, D.V., 2020. Functional parcellation of the default mode network: a large-scale meta-analysis. Sci. Rep. 10, 1–13. https://doi.org/10.1038/s41598-020-72317-8.
Whitfield-Gabrieli, S., Nieto-Castanon, A., 2012. Conn: a functional connectivity toolbox for correlated and anticorrelated brain networks. Brain Connect. 2, 125–141. https://doi.org/10.1089/brain.2012.0073.
Yeo, B.T.T., Krienen, F.M., Sepulcre, J., Sabuncu, M.R., Lashkari, D., Hollinshead, M., Roffman, J.L., Smoller, J.W., Zöllei, L., Polimeni, J.R., Fischl, B., Liu, H., Buckner, R. L., 2011. The organization of the human cerebral cortex estimated by intrinsic functional connectivity. J. Neurophysiol. 106, 1125–1165. https://doi.org/10.1152/jn.00338.2011.
Amaoui, S., Martín-Pérez C., Marín-Morales, A., Bueso-Izquierdo, N., García-León, MA., Pérez-García, M., Verdejo-Román, J., 2022. Resting-state functional connectivity and socioemotional processes in male perpetrators of Intimate Partner Violence Against Women. (under review).
The jamovi project (2021). jamovi (Version 1.6) [Computer Software]. Retrieved from https://www.jamovi.org.