Universidade do Minho
Escola de Psicologia

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Associations between childhood maltreatment and affective resonance responses during adolescence

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e da
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Despacho RT - 31 /2019 - Anexo 3

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Ana Raposo

(Ana Cristina Rodrigues Raposo)

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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

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Braga, 23 de Janeiro de 2023

Ana Raposo

(Ana Cristina Rodrigues Raposo)

De que forma os maus-tratos emocionais estão associados a resposta empática afetiva na adolescência

Resumo

Os maus-tratos na infância continuam a ser uma preocupação. Em 2021, a CPCJ respondeu a 45 132 alertas de perigo. A exposição crónica a estas situações prejudica o desenvolvimento socioemocional, impactuando mais quando começa cedo e persiste na primeira infância. A empatia, capacidade de compreendermos e experienciarmos o estado emocional do outro, é socialmente fundamental e moldada por disposições biológicas e experiências de cuidado. Integrando-a a ressonância afetiva, caraterizada pela partilha das emoções dos outros e pela ativação de uma rede neural (amígdala, a insula e o córtex cingulado médio). Assim, avaliamos a relação entre experiências de maus-tratos na infância e a capacidade de ressonância afetiva na adolescência, utilizando questionários de autorrelato e um paradigma de fMRI, numa amostra comunitária com 32 adolescentes do sexo masculino. Os resultados sugerem que, mesmo numa amostra sem experiências extremas de adversidade precoce, os maus-tratos totais associam-se negativamente a respostas comportamentais, perante expressões de valência negativa e positiva. Observamos ainda que o funcionamento cognitivo e a idade podem agir como fatores protetores. Finalmente, não verificamos associações entre maus-tratos precoces e a resposta neural a expressões faciais, podendo isto, ser justificado pelo tamanho da amostra e pela ausência de experiências extremas de maus-tratos.

Palavras-chave: correlatos neuro cognitivos, empatia afetiva, expressões faciais, maus-tratos precoces

Associations between childhood maltreatment and affective resonance responses during adolescence

Abstract

Childhood maltreatment continues to be a concern. In 2021, CPCJ responded to 45,132 alerts of danger. Chronic exposure to these situations impairs socio-emotional development, impacting more when it starts early and persists into early childhood. Empathy, the ability to understand and experience the emotional state of others, is socially fundamental and shaped by biological dispositions and caregiving experiences. Integrating it is affective resonance, characterized by the sharing of others' emotions and the activation of a neural network (amygdala, insula, and middle cingulate cortex). Therefore, we assessed the relationship between childhood maltreatment experiences and affective resonance capacity in adolescence using self-report questionnaires and an fMRI paradigm in a community-based sample of 32 adolescent males. Results suggest that, even in a sample without extreme experiences of early adversity, total maltreatment negatively associates with behavioral responses in the face of negative and positive valence expressions. We further observe that cognitive functioning and age may act as protective factors. Finally, we found no associations between early maltreatment and the neural response to facial expressions, which may be justified by the sample size and the absence of extreme maltreatment experiences.

Keywords: affective empathy, early maltreatment, facial expressions, neurocognitive correlates

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Introduction

Childhood Maltreatment

Maltreatment is defined by the World Health Organization as: "...abuse and neglect that occurs to children under 18 years of age. It includes all types of physical and/or emotional maltreatment, sexual abuse, neglect, and commercial or other exploitation that result in actual or potential harm to the child's health, survival, development, or dignity in the context of a relationship of responsibility, trust, or power".

In Portugal, in 2021, the *Comissão de Proteção de Crianças e Jovens* (CPCJ) received 45132 risk communications. Neglect was the most perpetrated type of maltreatment (31.01%), followed by domestic violence (26.53%). About the gender differences, these are not significant, however, there is a predominance of maltreatment against male (children and adolescents) (CPCJ, 2021). According to the World Health Organization, every year at least 55 million children in Europe suffer some form of physical, sexual, emotional, or psychological violence. In addition, 700 are murdered each year (ONU, 2020).

The consequences of childhood maltreatment range from neuropsychological changes (e.g. growth retardation, central nervous system damage, mental retardation, learning and speech disorders, and poor school performance), adverse psychological effects (e.g. depression, anxiety, substance abuse, and post-traumatic stress disorder), to social risk (e.g. risk of conduct disorders, school problems, delinquency, crime and violence in adolescence and young adulthood). However, it is important to keep in mind that not all maltreated children succumb to adverse childhood experiences or develop problematic behaviors (Widom, 2014).

Empathy

Empathy is one of the psychological abilities that has been consistently implicated in descriptions of disability due to maltreatment (Locher et al., 2014). Empathy is a multidimensional phenomenon that is characterized by the ability to resonate and reflect

on the feelings and mental states of others. It has been sculpted throughout the evolution of animals with the aim of increasing the survival of the species, providing group communication, and enabling social life (Levy et al., 2019). For a better understanding, it is important to distinguish the term empathy, which is often confused in the literature, with sympathy. While in empathy occurs a congruence of affective states with the other person, but with a distinction between self and the other, sympathy or compassion usually result in a feeling of love or affection for that person and a motivation to alleviate their suffering (Bernhardt & Singer, 2012; Decety & Michalska, 2010).

The empathic construct can be decomposed into two components: cognitive empathy akin to mentalization and affective empathy akin to affective resonance (Levy et al., 2019). Cognitive empathy is the ability to accurately predict and interpret the emotions of others, through observation or imagination of their experience (Moore et al., 2015; Lockwood, 2016). Alternatively, affective empathy is the ability to feel what the other is feeling, with a distinction being made between myself and the other. This involves an automatic response to the pain and feelings of others. It is also known, that during the empathic process, activation of the same brain networks involved in the first-hand experience of emotional states occurs (Levy et al., 2019; Moore et al., 2015).

Looking to the development of empathy, 18 to 72 hours after birth, babies exposed to the crying of another baby often exhibit distress reactions. The name of this phenomenon is "emotional contagion" (Mcdonald & Messinger, 2011). Indicating that the affective component of empathy, develops earlier, is involuntary and depends on facial mimicry. Which is understood as a tendency to synchronize another person's affective expressions, vocalizations, postures, and movements (Bernhardt & Singer, 2012; Lockwood, 2016). This primitive imitation mechanism occurs through mirror neurons and is observed in the parent-infant interaction. Where the former adapts his affective expression to the child's verbal and nonverbal cues. At the same time, this process is encoded in the brain, creating a template for the child's later emotional resonance with the feelings and thoughts of others. Thus, forming the neural basis of empathy in preadolescence (Decety & Michalska, 2010; Levy et al., 2019).

At the level of empathic behaviors, infants at 6 months show a preference for characters who help others, from 12 months on, they begin to comfort distress victims (Decety & Michalska, 2010). Until 18 months, the responses consist mainly of physical actions. These develop into helping behaviors such as giving verbal comfort, advice, and

attempts to distract the distressed person. Throughout the second year of life, the quality of prosocial behavior is developed. By the third, they engage in a variety of empathy-related behaviors, including expressing verbal and facial concern and interest in another's feelings of distress, and they continue to engage in a variety of helping behaviors. Cognitive empathy helps transform the early developing affective experience of empathy into a more sympathetic and focused experience by associating one person's empathetic feelings more fully with a conceptualization of another's experience rather than one's own (Levy et al., 2019; Mcdonald & Messinger, 2011). However, a decline in cognitive empathy is observed with advancing age, in contrast to affective empathy, which appears more stable or may even increase with age (Moore et al., 2015).

Regarding the neural basis of empathy, cognitive empathy is subserved by the temporal parietal junction, the superior temporal sulcus, the medial prefrontal cortex, the posterior cingulate cortex (PCC), and the temporal pole.

Affective empathy, the focus of this study, appears to be subserved by a distinct brain network. Seminal studies, concerning the experience of pain and other negative affective states, as well as the anticipation of these states (e.g. Singer et al., 2004 and Bernhardt & Singer, 2012), suggest that affective empathic responses involve, to some extent, brain areas such as those involved during first-hand experience, such as the anterior insula, dorsal anterior cingulate cortex (dACC), brainstem, and cerebellums. Regarding the experiencing of emotional stimuli, in general, these confirm the recruitment of the anterior insula, dACC, and inferior frontal gyrus. The former is critical for sensory integration and interoceptive awareness of all subjective feelings, and all three structures are important in processing faces, pain, and disgust. In addition to these, the amygdala is also recruited, which is believed to be involved in the detection of emotional salience of both positive and negative stimuli (Seara-Cardoso et al., 2016).

Effect of maltreatment on empathy

Behavioural changes

In 2014 Locher and collaborators conducted a study, dividing participants into three groups: control, moderate maltreatment, and severe maltreatment. These were asked to watch videos of dialogues between victims and perpetrators of severe human rights violations. They concluded that individuals with moderate levels of maltreatment

avoid distressing stimuli, which may be related to an overly controlled pattern of emotion regulation. In the severe maltreatment group, the response to this same stimulus is intense and uncontrollable emotional distress, furthermore, the data from this group suggests a pattern of decreased cognitive empathy and sympathy and increased emotional contagion. These affective empathy deficits can be explained by the internalization of parental behavior as well as a negative worldview.

In a study by Shenk and colleagues (2013) aimed to understand whether child maltreatment affects face recognition accuracy differently given cognitive ability. Thus, a sample of maltreated (n= 50) and non-maltreated (n= 56) adolescent females was used. An experimental paradigm was used, that recorded a reactive facial affect, starting with a neutral expression and changing into a full expression of one of six emotions: happiness, sadness, anger, disgust, fear, or surprise. They found that the capacity for emotional recognition did not vary according to the subtype of maltreatment, physical abuse, sexual abuse, or neglect. However, this study found a significant relationship between cognitive ability and facial affect recognition, with maltreated women with lower cognitive ability being less accurate at recognizing facial affect.

However, there is a large literature that different types of maltreatment are associated with different consequences. For example, Berzenski e Yates (2022) conducted a longitudinal study with children and their caregivers from ages 6 to 8. They concluded that experiences of emotional abuse and neglect predicted declines in empathy, while physical abuse and childhood exposure to domestic violence predicted increases in empathy between the ages of 6 and 8. Also taking subtypes into consideration, Pollak and colleagues (2000), compared the ability of three groups of preschool children (non-abused, physically neglected, and physically abused) to recognize emotions through contextual cues. Noting that the neglected children have, as in Levy et al. (2019) study, difficulties in discriminating emotional expressions, which may be the result of the impoverished opportunities they have for interaction with adults. Whereas those who have been physically abused, show difficulties in recognizing emotions such as sadness and disgust and a "normative" ability to recognize anger, which may be explained by the aggression they experience from their parents. Another finding was that both physically abused, and physically neglected children rated expressions of anger and sadness as very similar to an emotionally neutral face.

In sum, although studies do not converge regarding the individual influence that the various types of maltreatment may have. They agree that positive representations of self and caregivers, cognitive functioning, and the quality of the caregiver-child relationship, can protect against the negative influences of family conflict (Shenk et al., 2013; Berzenski & Yates, 2022).

Brain changes associated to maltreatment

In a 2016 literature review of the neurobiological effects of abuse, the authors found that childhood abuse is in general associated with changes in brain structure and function. Being noted that these changes vary depending on the type of maltreatment and the age at which exposure occurred. The explanatory hypothesis, raised by these authors, is that the brain of abused children is developing in a stressful environment. In order to adapt to this, there may be an increased production of neurotransmitters, such as glucocorticoids, which affect the normal development of neural regions more susceptible to stress, such as the hippocampus, amygdala, neocortex, cerebellum, and white matter tracts (Teicher & Samson, 2016).

At the structural level, we can find an increase in amygdala volume in children exposed to caregiver neglect, however a reduction is seen when it comes to abuse situations or in samples with mixed exposures. Similarly, a reduction in the hippocampus in adults with a history of maltreatment is reported in the literature, but this reduction is rarely found in victims of neglect (Cassiers et al., 2018; Mclaughlin et al., 2019; Teicher & Samson, 2016).

During vicarious experience, functional neural-level responses occur in the amygdala, anterior insula, and anterior cingulate cortex (Lockwood, 2016; Moore et al., 2015). Since that the functional level is the focus of our study, it is essential to survey previous studies on the topic. As for the amygdala plays an important role in emotional regulation and learning relative to environmental stimuli throughout development (Cheng et al., 2021). It is also involved in the detection and processing of threatening stimuli (Mclaughlin et al., 2019).

In a study by McCrory et al. (2013) a group of children who had experienced maltreatment was contrasted with one from the normal population. The task consisted of

viewing a facial expression of anger or happiness, which would be paired with a neutral facial expression of the same actor. After the brief presentation of two faces, they were shuffled, and participants indicated on which side of the screen the asterisk was displayed. The results showed an activation of the right amygdala for both positive (happy) and negative (angry) affect faces. It was also found that the increased amygdala response was associated with earlier onset in cases of emotional abuse and neglect. In conclusion, there is a pattern of "hypervigilant" amygdala response to both threat-related signals in children exposed to different forms of early adversity, and to happy faces. High reactivity in the amygdala is also reported in the review by Mclaughlin et al. (2019), in response to negative social images; to angry; fearful and both sad and happy faces relative to neutral faces in child victims of maltreatment (violence or abuse). A bilateral activation in the amygdala, to neutral and happy faces, is further verified in the literature review by Van Harmelen et al., (2013), in individuals who reported childhood neglect and emotional abuse. There is, however, little relationship with neutral faces.

The insula has been linked to the processing of subjective feelings and uncertainty, as well as empathy. Also, the anterior insula, related to the integration of interoceptive and visceral information, has been implicated in emotional experience. In the literature review by Hein and Monk (2017) it is reported that during the process of affective resonance, hyperactivation of the insula occurs in individuals with traumatic experiences when they are faced with an emotional stimulus. Furthermore, according to the literature review by Cassiers et al. (2018), which relied on neuroimaging studies conducted between 2017 to 2018. They concluded that in cases of neglect a reduced connection in the insular network occurs, this change can be considered adaptive as it reduces the experience of adverse bodily sensations (e.g. hunger, pain) or emotions (e.g. feelings of low self-esteem, loneliness, rejection) that can accompany neglect. The same is not reported in the literature review by Mclaughlin and colleagues (2019), where only a few of the studies reviewed, regarding violence or abuse against children report increased activation in the insula, and no activation in the insula is observed in samples that experienced deprivation or mixed maltreatment.

Aim of the study

Considering the relatively scarce research regarding the effects of maltreatment on empathy and the differential influence of maltreatment subtypes on this process, this thesis aims to study the impact of childhood maltreatment on the affective empathy response in adolescence at the neural and behavioral levels in a community sample. More specifically, we aim to understand how various maltreatment (physical abuse, emotional abuse, sexual abuse, physical neglect, and emotional neglect) and the cumulative experience of those, are associated with affective resonance at the behavioral and neural levels. We also aim to understand how changes in affective empathy at the neural level are also observed at the behavioral level. Based on the literature review, we aim to test the following hypotheses: (a) emotional maltreatment is negatively associated with trait affective empathy; (b) maltreatment is negatively associated with affective resonance response to emotional facial expression during the behavioral task; (c) maltreatment are associated with increased activity in insula and amygdala during affective resonance response to emotional faces.

Method

Participants

The sample was recruited from the general population through media advertisements and consisted of 32 right-handed male participants between the ages of 14 and 18 (M = 16.06; SD = 1.523), having an education level between junior high and high school. Exclusion criteria included a history of psychiatric or neurological disorders, history of head trauma, presence of electronic or other implants, and current drug use. In addition, one of the participants did not complete the maltreatment questionnaire and was therefore removed from the analyses.

About substance abuse, only three participants reported prior drug use, specifically cannabis, but not in the 24 hours prior to the task, furthermore, they reported no other drug use or potential drug-related problems. Two participants reported a total score greater than eight, one participant scored a total score of eight, and twelve participants scored a total score less than eight on the Alcohol Use Disorder Identification Test. Total scores between eight and 15 are most appropriate for guidance related to

reducing hazardous alcohol consumption (Babor et al., 2001). With this in mind, they were not excluded from the analyses.

Measures

Assessment of cognitive ability

In the first phase, the participants answered a sociodemographic questionnaire and an instrument measuring cognitive ability, and then two self-report questionnaires. The instrument used to measure cognitive ability was the Wechsler Intelligence Scale for Children (WISC-V), specifically the Vocabulary subtest. This is included in the verbal subtests, and provides information on concept development, and verbal reasoning. The raw scores were converted to standardized scores and used as a proxy measure of cognitive functioning. The vocabulary subtest is the best predictor of overall IQ (Wechsler,2014; Jensen, 2001).

Assessment of maltreatment

The first self-report questionnaire was the Childhood Trauma Questionnaire (CTQ-SF) (Bernstein & Fink, 1998, validated for the Portuguese population by Dias et al., 2013, in a non-clinical sample). It was used in this study to assess the participants' exposure to maltreatment up to the age of 15. It contains 5 types of subscales, referring to maltreatment: emotional abuse, physical abuse, sexual abuse, physical neglect, and emotional neglect. There is also a general indicator of exposure to maltreatment, resulting from the sum of the subscales.

The questionnaire contains 28 items, which describe childhood experiences of both maltreatment and caregiving experiences and are rated on a 5-point Likert scale: with "1" meaning "never", "2- a few times", "3 - sometimes", "4 - often" or "5 - always". The rating was reversed for items describing a unpleasant experience (Dias et al., 2013).

Assessment of empathy

The second self-report questionnaire used in this study aimed to assess the affective and cognitive components of empathy. To this end, we used the Basic Empathy Scale (BES) questionnaire (Jolliffe & Farrington, 2006; Portuguese version: Pechorro et

al., 2018). The original version of this scale is composed of two subscales: the affective empathy scale, composed of 11 items, and the cognitive empathy scale, composed of 9 items. Responses are given on a five-point Likert scale, ranging from "strongly disagree" (1) to "strongly agree" (5). Internal consistency (reliability) revealed values always above .70 (Dunn et al., 2014; Nunnally, & Bernstein, 1994) for the total scale and the two dimensions (Pechorro et al., 2015; Anastácio et al., 2016).

Empathy paradigm

After completing the two questionnaires, participants performed the Empathy Task for Emotional Facial Expressions, described by Seara-Cardoso et al. (2016), within the MRI scanner to assess affective empathy at the behavioral and neural levels. Before entering the scanner, participants were familiarized with the instructions. Once inside, they performed the task that consisted of 48 trials presented randomly with different stimuli. These stimuli corresponded to faces with two emotional expressions: happiness, sadness, and a neutral face. Each expression was represented in 16 images, 8 female and 8 male, and half of the faces were adults, and the rest were young. Each trial lasted a maximum of 6.5sec, starting with the presentation of a facial stimulus for 2s, then a scale appeared next to the stimulus, on which the participant marked from -3 (very bad) to +3 (very good), how the facial expression made him/her feel. If an answer was not given within 4s, it was considered wrong. To record their subjective states, participants moved a cursor on a sliding scale using a keyboard with three keys, one to move the cursor left, one right, and one for the mark their response. After marking the response, participants received visual confirmation of their response for 0.5 seconds, and for 2s a fixed cross appeared, before the next trial. The participants also had three 15s pause periods, in which the screen displayed "This is a short pause. Please be quiet for a few seconds.". The task presentation and response collection were implemented with Cogent running in Matlab R2019a (http://mathworks.com). An example of the task depicted in figure 1.

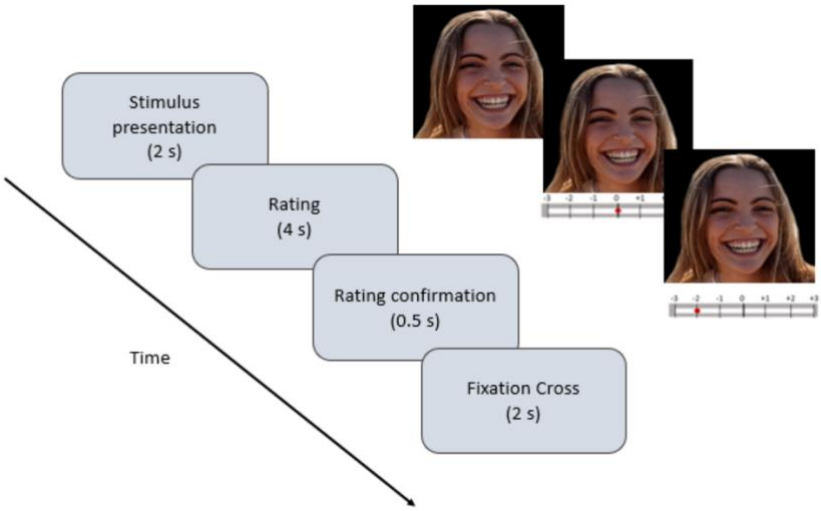

Figure 1 - *Empathy Task for Emotional Facial Expressions*

Note. Empathy for faces task timeline with an example one trial. Two screens were presented to participants across each trial, one with the presentation of the emotional stimuli (2s) followed by presentation of the sliding scale where they had to rate how the facial expression made them feel (0-4s).

fMRI acquisition

While participants were performing the task described above, neural images were acquired using a Siemens Verio 3T MRI scanner at Serviços Médicos de Imagem Computorizada (SMIC) in Casa de Saúde da Boavista. A 32-channel head coil was used to acquire a 5.5 min 3D T1- weighted anatomical scan and multislice T2*-weighted echo-planar images (EPIs). The acquisition parameters for the T2*EPI sequence were matrix size= 66x66 mm, field of view: 200x200 mm, the slice order acquisition was performed with alternated slices. It also acquired 42 slices with a thickness of 3mm ad with o gap between the echo time of 22ms, flip angle of 60o, and a repetition time of 2980ms. The functional data were acquired in a single run. Additionally, field maps were obtained to be used in the unwarping stage of the data preprocessing.

Data analysis

Behavioral data analysis

Behavioral data were analyzed in IBM Statistical Package for the Social Sciences (SPSS), version 28. An exploratory analysis of the data was performed, which revealed that the assumptions underlying the use of parametric tests were not met, particularly in

the variables related to maltreatment, so we employed Spearman's Rho correlations. Furthermore, through a descriptive analysis of the data, focusing on the dispersion of responses and their frequency, we found that no variability occurred in the sexual and physical abuse subscales, with over 85% of participants scoring the same on both subscales (as shown in Table 1). Thus, these subscales, were not subjected to further analyses. Since three participants reported cannabis use in the past 30 days, a supplementary set of analyses was conducted excluding these participants.

To test the association between trait empathy and the experience of early adversity, we conducted Spearman's Rho correlation analyses between the subscales and total score of the empathy questionnaire (BES) and the subscales and total score of the maltreatment questionnaire (CTQ). Next, we conducted a partial correlation analysis controlling for the variables cognitive ability and age. To test the association between empathic resonance to sad and happy faces and the experience of early adversity, we conducted Spearman's Rho correlations between the different expressions (neutral, happy and sad) and the subscales of the maltreatment questionnaire (CTQ). We then conducted partial correlations analyses controlling for the variables cognitive ability and age. For interpretation sake, participants' scores on the sad condition were reversed. Lower scores on the empathy task equates lower empathic resonance and higher scores equates stronger empathic resonance with the stimuli.

fMRI data analysis

Imaging preprocessing. Imaging data were preprocessed and analyzed using Statistical Parametric Mapping 12 (www.fil.ion.ucl.ac.uk/spm). Preprocessing was performed using a standard sequence pipeline. The first five volumes were discarded, and the data were realigned to the sixth volume, unwarped using a field map, normalized to the Montreal Neurological Institute (MNI) template, and then coregistered to the subject's anatomical image. Realignment ensures that all scans belonging to the same participant are collected at set borders. The heterogeneity of the size and shape of participant´s brains required the normalization of the anatomical images by applying a combined segmentation procedure [95], consisting of bias correction, segmentation and estimation of the distortions or wrapping required to map the anatomical image unto MNI space. Following this segmentation, the previous warps were applied to the EPI data and each voxel size was resampled to 1.5X1.5X1.5 mm. Finally, to smooth the images spatially, a

Gaussian kernel of 8mm FWHM was applied. Nine participants presented bad scans due to excessive motion. Bad scans were removed and replaced with an image generated by interpolating the two adjacent images. An additional regressor for bad scans was added to these participant´s first-level SPM models.

SPSS Analysis of Neural Data. For the neural data, the same methodology was followed as for the behavioral analysis. Here we inspected neural response to emotional facial expressions by contrasting responses during emotional conditions (happy and/or sad) relative to neutral condition. To inspect the association between the neural response (insula, amygdala and midcingulate) and experience of maltreatment, we conducted correlation analyses with Spearman´s Rho. Subsequently, partial correlation analyses were performed, controlling for the variables cognitive ability and age.

Results

Descriptive analyses

Our sample has a cognitive ability ranging from 1 to 17 (M= 9.28; SD= 3.66). The results regarding the questionnaires and the behavioral responses to the empathy task, are presented in Table 1. However, although descriptive statistics were presented for the sexual and physical abuse subscales, these were not subjected to analysis for the reasons stated in the methods.

Table 1. *Descriptive statistics of the questionnaires and the empathy task*

	Mín	Máx	M	SD	Skewness	Kurtosis	p.value
Questionnaires							
Childhood Trauma Questionnaire (Bernstein & Fink, 1998)							

Emotional Abuse	5.00	14.00	6.93	2.48	1.33	1.09	<.001
Emotional Neglect	5.00	16.00	8.06	3.02	1.16	0.50	.003
Sexual Abuse	5.00	9.00	5.38	1.10	2.90	7.22	<.001
Physical Abuse	5.00	8.00	5.09	0.53	5.66	32.00	<.001
Physical neglect	4.00	8.00	5.53	1.11	1.06	0.43	<.001
Total	24.00	47.0	31.00	5.95	1.35	1.53	<.001
Basic Empathy Scale (Jolliffe & Farrington, 2006)							
Affective Empathy	13.00	39.00	31.03	5.76	-1.05	1.97	.200
Cognitive Empathy	19.00	40.00	32.50	5.54	-0.59	-0.17	.200
Total	43.00	79.00	63.53	8.91	-0.24	-0.22	.200
Empathy Task for Emotional Facial Expressions (Behavioral response) (Seara-Cardoso et al. 2016)							
Empathy for sad expressions	0.08	2.44	1.21	0.57	-.07	-.30	.200
Empathy for neutral expressions	-0.65	0.69	0.004	0.23	.282	3.29	.042
Empathy for happy expressions	-0.02	2.93	1.32	0.81	0.01	-1.00	.200

Note

Questionnaire results

Is there an association between early adversity and empathy traits during adolescence?

Doing the Spearman´s Rho correlation coefficient analyses, no significant relationship was obtained between the total maltreatment score with affective empathy (r= -.243, p=.180), nor even with cognitive empathy (r= -.024 p=.897), or total empathy (r= -.206, p=.258). Regarding the subtypes of maltreatment, no significant correlations were found with the types of empathy or total empathy, as shown in Table 2. but when we control for the effect of the variables cognitive ability and age, the relationship

between emotional neglect and total maltreatment score becomes significant (r=-.406, p=.026).

With regard to the non-parametric and partial correlations, performed without the three individuals with cannabis use, the results were also not significant (Table 8 and 9).

Table 2. *Associations between the responses to the CTQ questionnaire and the Basic Empathy Questionnaire*

Variables	1.	2.	3.	4.	5.	6.	7.
1. Emotional Abuse (CTQ)	1						
2. Emotional Neglect (CTQ)	**.650****	1					
3. Physical Neglect (CTQ)	**.539****	**.535***	1				
4. Total (CTQ)	**.837****	**.831****	**.735****	1			
5. Affective Empathy (BES)	-.250	-.236	.019	-.243	1		
6. Cognitive Empathy (BES)	.086	-.156	.140	-.024	**.350***	1	
7. Total (BES)	-.163	-.274	.084	-.206	**.818****	**.788****	1

Table 3. *Associations between the responses to the CTQ questionnaire and the Basic Empathy Questionnaire* with variables age and cognitive ability controlled

Variables	1.	2.	3.	4.	5.	6.	7.
Control Variable: Age and cognitive ability							
1. Emotional Abuse (CTQ)	1						
2. Emotional Neglect (CTQ)	**.713****	1					
3. Physical Neglect (CTQ)	**.458***	**.475***	1				

4. Total	**.894****	**.891****	**.644****	1			
5. Affective Empathy (BES)	-.304	-.341	.107	-.290	1		
6. Cognitive Empathy (BES)	-.056	-.321	.061	-.125	.329	1	
7. Total (BES)	-.232	**-.406***	.105	-.262	**.845****	**.783****	1

Empathy task

Is there an association between early adversity and affective response to facial expressions?

To understand how the various types of maltreatment related to the affective responses to the facial expressions present in the task (happiness, sadness and neutral expression), correlations with Spearman´s Rho Coefficient were performed. The results showed that there is a significant negative correlation between the total maltreatment score and the affective response to sad expressions, (r= -.497, p= .004) and to happy expressions (r= -.544, p=.001). In relation to the different types of maltreatment, emotional abuse showed a significant and negative correlation with sad expressions (r= -.506, p= .003) and with happy expressions (r= -.569, p= .001). Also, emotional neglect showed similar association with the emotional expressions: sad (r= -.439, p= .012) and happy (r= -.418, p= .017). No association was found with neutral faces, as shown in Table 4.

After these, correlations were conducted controlling for age and cognitive ability (Table 5). The total maltreatment score remained significantly and negatively correlated with empathy for sad faces (r= -.417; p=.022) and for happy faces (r= -.405 p=.026). The same was true for the relationship between emotional abuse and the affective response to sad (r= -.461, p=.010) and happy faces (r= -.512, p=.004). On the other hand, the relationship between emotional neglect and affective response was no longer significant.

In terms of the analysis without participants who reported cannabis use, there were no changes in the patterns of the results, neither in the correlations with Spearman's Rho Coefficient, even when controlling for age and cognitive ability.

Table 4. *Associations between the responses to the CTQ questionnaire and the results of the Empathy task*

Variables	1.	2.	3.	4.	5.	6.	7.
1. Emotional Abuse (CTQ)	1						
2. Emotional Neglect (CTQ)	**.650****	1					
3. Physical Abuse (CTQ)	**.539****	**.535****	1				
4. Total (CTQ)	**.837****	**.831****	**,735****	1			
5. Empathy for sad faces	**-.506****	**-.439***	-.157	**-,497****	1		
6. Empathy for neutral faces	.069	.068	-.121	-.039	-.349	1	
7. Empathy for happy faces	**-.569****	**-.418***	-.214	**-,544****	**,823****	-.037	1

Table 5. *Associations between the responses to the CTQ questionnaire and the behavior results of the Empathy task with variables age and cognitive ability controlled*

Variables	1.	2.	3.	4.	5.	6.	7.
Control Variable: Age and cognitive ability							
1. Emotional Abuse (CTQ)	1						
2. Emotional Neglect (CTQ)	**.713****	1					
3. Physical Neglect (CTQ)	**.458***	**.475****	1				
4. Total	**.894****	**.891****	**.644****	1			
5. Empathy for sad faces	**-.461***	-.350	-.033	**-.417**	1		
6. Empathy for neutral faces	.142	.064	-.111	.106	-.289	1	

7. Empathy for happy faces	**-,512***	-.287	.022	**-,405***	**,796****	-.139	1

Is there an association between early adversity and neural response to facial expressions?

Regarding the analyses of neural responses to the task, Spearman´s Rho correlations were performed between neural responses extracted from regions-of-interest during the task (as described in the section above) and experience on maltreatment variables. No statistically significant correlations were found, even after controlling for cognitive ability and age (tables 7 and 8).

In terms of the analysis without participants who reported cannabis use, there were no changes in the patterns of the results, neither in the correlations with Spearman's Rho Coefficient, even when controlling for age and cognitive ability (table 13 and 14).

Table 6. *Associations between the responses to the CTQ questionnaire and the neural results of the Empathy task*

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. Emotional Abuse (CTQ)	1														
2. Emotional Neglect (CTQ)	**.650****	1													
3. Physical neglect (CTQ)	**.539****	**.535****	1												
4. Total (CTQ)	**.837****	**.831****	**.735****	1											
5. Left insula sad and happy	.065	-.085	.059	.048	1										
6. Left insula sad and neutral	-.039	-.199	-.019	-.161	**.546****	1									
7. Left insula happy and neutral	.085	-.092	.057	.075	**.908****	**,513****	1								
8. Left insula happy and neutral – second observation	.037	-.166	-.087	-.123	**.536****	**.897****	**.517****	1							
9. Right insula sad and happy	.082	.128	.015	.176	**.698****	.292	**.722****	**.374***	1						
10. Right insula sad and neutral	-.134	-.182	-.198	-.141	**.747****	**.449****	**.742****	**.456****	**.661****	1					
11. Amygdala sad and happy	.106	.225	.023	.139	**.525****	.262	**.505****	.140	**.391***	**.419***	1				
12. Left Amygdala happy and neutral	.134	.219	.108	.151	**.677****	.270	**.672****	.209	**.533****	**.556****	**.914****	1			
13. Left Midcingulate cortex sad and happy	.258	.129	.073	.280	**.585****	.171	**.663****	.237	**.691****	**.398***	**.389***	**.439***	1		
14. Left Midcingulate cortex sad and neutral	.270	.081	.010	.217	**.569****	.293	**.592****	**.375***	**.640****	.290	.305	.349	**.896****	1	
15. Left Midcingulate cortex happy and neutral	.278	.143	.087	.299	**.589****	.206	**.672****	.255	**.701****	**.441***	**.469****	**.495****	**.963****	**.818****	1

Table 7. *Associations between the responses to the CTQ questionnaire and the neural results of the Empathy task with variables age and cognitive ability controlled*

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. Emotional Abuse (CTQ)	1														
2. Emotional Neglect (CTQ)	**.650****	1													
3. Physical neglect (CTQ)	**.539****	**.535****	1												
4. Total (CTQ)	**.837****	**.831****	**.735****	1											
5. Left insula sad and happy	.065	-.085	.059	.048	1										
6. Left insula sad and neutral	-.039	-.199	-.019	-.161	**.546****	1									
7. Left insula happy and neutral	.085	-.092	.057	.075	**.908****	**,513****	1								
8. Left insula happy and neutral – second observation	.037	-.166	-.087	-.123	**.536****	**.897****	**.517****	1							
9. Right insula sad and happy	.082	.128	.015	.176	**.698****	.292	**.722****	**.374***	1						
10. Right insula sad and neutral	-.134	-.182	-.198	-.141	**.747****	**.449****	**.742****	**.456****	**.661****	1					
11. Amygdala sad and happy	.106	.225	.023	.139	**.525****	.262	**.505****	.140	**.391***	**.419***	1				
12. Left Amygdala happy and neutral	.134	.219	.108	.151	**.677****	.270	**.672****	.209	**.533****	**.556****	**.914****	1			

13. Left Midcingulate cortex sad and happy	.258	.129	.073	.280	**.585****	.171	**.663****	.237	**.691****	**.398***	**.389***	**.439***	1		
14. Left Midcingulate cortex sad and neutral	.270	.081	.010	.217	**.569****	.293	**.592****	**.375***	**.640****	.290	.305	.349	**.896****	1	
15. Left Midcingulate cortex happy and neutral	.278	.143	.087	.299	**.589****	.206	**.672****	.255	**.701****	**.441***	**.469****	**.495****	**.963****	**.818****	1

Note.

Neural response indicates the response in an area of the brain to a certain condition in contrast to neutral expressions

Discussion

The main purpose of our study was to assess how child maltreatment relates to affective empathic responding in adolescence. Despite the few studies concerning this topic, the existing ones point to associations between child maltreatment experiences and empathy deficits in children.

In order to explore this issue, we used a self-report empathy and maltreatment questionnaire, as well as a functional MRI affective resonance imaging paradigm, in a community sample of 32 adolescent males. We found that maltreatment is negatively related, with positive and negative valence expressions, in the empathic task. No relationship was observed with affective or cognitive empathy, nor with total, and no changes were observed at the neural level. Our results suggest that, even in normative ranges of maltreatment experiences, such as those found in community samples, maltreatment during childhood is negatively associated with affective components of empathy. Our results further suggest that age and cognitive function may act as protective factors.

It is important to note that the most prevalent maltreatment in our sample is emotional maltreatment, emotional neglect, followed by emotional abuse. This agrees with the CPCJ data of 2021, which report that neglect is one of the most suffered maltreatments in Portugal. Furthermore, studies repeatedly show that emotional maltreatment is present in 75% to 90% of known cases of physical abuse or neglect and the most lasting and damaging effects of physical abuse, sexual abuse and neglect are psychological in nature and may be a manifestation of the underlying emotional maltreatment (Campbell, 2014).

First, we observed that emotional maltreatment is negatively related to affective empathy traits, as hypothesized. This, only having been true in behavioral responses to the empathy task. Thus, these results are in agreement with the literature (Berzenski & Yates, 2022), which demonstrates strong negative associations between emotional abuse and neglect with global empathy traits. These results can be explained by the fact that both emotionally abusive and neglectful parents may themselves exhibit lower levels of empathy (Rodrigo et al., 2020), which can be transmitted to children genetically and/or through compromised social interactions (Berzenski & Yates, 2022). However, these findings should be interpreted with caution as our sample shows no variability in

exposure to physical abuse and physical neglect, we cannot conclude that this relationship is specific to emotional abuse as we could not test for physical maltreatment.

It was also observed that a higher level of maltreatment is associated with a lower affective response to faces that exhibit both positive and negative valence emotion, as hypothesized. However, the existing literature, has only been devoted to studying the relationship between maltreatment and the cognitive component of empathy, which is responsible for understanding the emotional state of the other (Locher et al, 2014). In one such study, the authors observed that children who have experienced neglect have difficulty distinguishing joy from sadness, just as they also classify a neutral expression as very similar to negative valence expressions (Pollak et al., 2000). These results, from the two components of empathy, reveal that maltreatment is associated with difficulties in empathic processing at several levels.

The correlation between emotional neglect and behavioral response for both joy and sadness ceases to be significant when controlling for the effect of the variables age and cognitive ability. This is interesting because it points to a putative role of age and cognitive ability on these associations. It has been noted previously in the literature (e.g., Shenk et al., 2013 and Berzenski & Yates, 2022) that cognitive ability can act as a protective factor in individuals who have experienced maltreatment when they are faced with empathic processing. For example, Shenk and colleagues (2013) observed that maltreated females with higher levels of cognitive ability perform the emotional recognition task with the same accuracy as their non-maltreated counterparts, whilst this was not true for maltreated females with lower levels of cognitive ability. This suggests that higher levels of cognitive ability served a protective function for these maltreated females.

The fact that we found stronger associations in the behavioral task of empathy, may be related to the fact that self-report measures (CTQ-SF and BES) which, according to the literature, are associated with lower reliability as they may influence participants to have a desirably social response and are also based on subjective perceptions and judgments (Dang et al., 2020).

Finally, regarding our hypothesis that maltreatment would be associated with increased activity in insula and amygdala during affective resonance response to emotional faces, we did not find any significant association between these variables. These results are discordant with those found in other studies. In a meta-analysis by

Teicher and Samson (2016), they identified nine functional imaging studies, which consisted of assessing response to emotional faces, and all are consistent in reporting that maltreatment is associated with greater amygdala-activity to emotional faces, the same results were found in another meta-analysis by Hein and Monk (2017). In another study, with adults with a history of emotional maltreatment, they examined amygdala reactivity to emotional faces (Angry, Fearful, Sad, Happy and Neutral), and found that emotional maltreatment was associated with greater bilateral amygdala reactivity to emotional faces in general, and independent of psychiatric status (Harmelen et al., 2013). Regarding the insula, in a quantitative meta-analysis Shenk and colleagues (2017) concluded that the insula is hyperactive in maltreated individuals. In another study, also a literature review, they observed that the anterior insula is hyperactive in individuals with adverse childhood experiences when exposed to emotional stimuli compared to neutral stimuli (Herzog, 2018). However, in Levy and colleagues' (2019) study on the impact of childhood exposure to war, they found no correlations between maltreatments and neural activity, they justified this by the fact that neural data may be more sensitive to certain unconscious or even conscious empathic processes than self-report questions. Our negative findings can be explained by a number of reasons, including the limited size of our sample and the methodological approach for these analyses, as will be discussed further below.

Limitations

This study has limitations that must be considered. First, the sample size is small and consists only of males. This prevents the generalizations for the study population and may also be the main reason why some of the results did not reach statistical significance. A second limitation, which prevented the different types of maltreatment from being analyzed individually or compared to each other. This was due to the fact that the sexual and physical maltreatment subscales showed constant results, and therefore no discriminatory power with the remaining subscales (emotional abuse, emotional neglect, and physical neglect), so that only the total maltreatment subscale could be analyzed. One of the reasons for this may be that the sample was not clinical and consisted only of young

males, and sexual abuse is notably more frequently perpetrated against girls (60.8%) (CPCJ, 2021).

Valid inferences are only possible if an experiment is designed in a way that excludes causal effects or alternative interactions. Thus, in this study we control for the effect of variables such as age and cognitive ability, to do this we proceed using partial correlation, this method looks at the relationship between two variables while 'controlling' for the effect of one or more additional variables. In the first step, we enter the variables to be controlled and in the next step the predictors whose effect has to be evaluated (after controlling for some other variables). Finally, ANCOVA is a technique that removes the impact of one or more undesirable variables on the metric scale of the dependent variable before the investigation is undertaken. The latter has other advantages, such as reducing the within-group error variance, allowing us to assess the effect of the independent variable more accurately, and eliminating confounders: In any experiment, there may be unmeasured variables that confound the results. Once a possible confounding variable is identified, it can be measured and entered the analysis as a covariate.

Other methods that could be used to test the hypotheses would be to conduct a mixed analysis, with an interview being conducted with open-ended questions that explored emotions and thoughts evoked by the expressions present in the empathy task (Locher et al., 2014), with this being conducted in place of the behavioral empathy task. Furthermore, in addition to the participant maltreatment questionnaire, a parent questionnaire could also be conducted regarding maltreatment experiences (Berzenski & Yates, 2022), allowing for the recording of any form of maltreatment that participants may not remember because they were too young at the time of the event.

Future Directions

For future studies, it would be interesting to attach the angry expression to the empathy task, since in studies concerning cognitive empathy these one, present quite interesting results. For example, in the study by Pollak and collaborators (2000) they found that physically abused children as well as physically neglected children rated

expressions of anger and sadness as very similar to an emotionally neutral face exemplar (Pollak et al., 2000)

Furthermore, the addition of a group of institutionalized children, which could be compared to the sample in this study, would provide a more comprehensive perspective regarding maltreatment in the institutionalized vs. normative population. Regarding the variables used in this study, the fact that when we controlled for age and cognitive ability, they yielded different results, and the fact that there is emerging evidence of sensitive exposure periods for the hippocampus, amygdala, prefrontal cortex, occipital cortex, and inferior longitudinal fasciculus, makes us believe that in another age group the results would be different (Teicher, 2006). Therefore, it would be interesting to use a longitudinal design to understand the impact of maltreatment throughout development. Regarding neural data, something that would bring more robustness to the study would be to perform a whole-brain analysis, after analyzing the areas of interest (ROI), checking if there are more areas of interest, than just those that were analyzed (Hein & Monk, 2017). Finally, at the level of methodologies, the use of an attachment questionnaire would also bring greater rigor to the study, as several studies report that this variable has a mediating effect between maltreatment and empathic responding (Levy et al., 2019).

In summary, this study examined the relationship between child maltreatment and affective empathy in adolescence in a community sample. The results of this study suggest that maltreatment is related to lower levels of affective empathy and that cognitive functioning may act as a protective factor. Therefore, it is important to invest in prevention measure. Further studies are still needed to understand the changes in the most significant and clinical samples (Shenk, 2013).

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Attachments

Table 8. *Correlational analyses between the CTQ questionnaire and the Basic Empathy Questionnaire*

Variables	1.	2.	3.	4.	5.	6.	7.
1. Emotional Abuse (CTQ)	1						
2. Emotional Neglect (CTQ)	**.719****	1					
3. Physical Neglect (CTQ)	**.517****	**.628****	1				
4. Total (CTQ)	**.836****	**.877****	**.740****	1			
5. Affective Empathy (BES)	-.193	-.235	.076	-.194	1		
6. Cognitive Empathy (BES)	.149	-.138	.132	.015	.301	1	
7. Total (BES)	-.105	-.278	.099	-.176	**.813****	**.766****	1

Table 9. Partial Correlational analyses between the CTQ questionnaire and the behavior results of the *Basic Empathy Questionnaire* with variables age and cognitive ability controlled

Variables	1.	2.	3.	4.	5.	6.	7.
Control Variable: Age and cognitive ability							
1. Emotional Abuse (CTQ)	1						
2. Emotional Neglect (CTQ)	**.725****	1					
3. Physical Neglect (CTQ)	**.493***	**.637****	1				
4. Total	**.888****	**.906****	**.681****	1			
5. Affective Empathy (BES)	-.229	-.307	.212	-0,23	1		
6. Cognitive Empathy (BES)	-.002	-.302	.089	-0,084	.294	1	
7. Total (BES)	-.152	-.378	.142	-0,201	**.829****	**.778****	1

Table 10. Correlational analyses between the CTQ questionnaire and the behavior results of the Empathy task

Variables	1.	2.	3.	4.	5.	6.	7.
1. Emotional Abuse (CTQ)	1						
2. Emotional Neglect (CTQ)	**.719****	1					
3. Physical Abuse (CTQ)	**.517****	**.628***	1				
4. Total (CTQ)	**.836****	**.877****	**.740****	1			
5. Empathy for sad faces	**-.661****	**-.462***	-.213	**-.596****	1		
6. Empathy for neutral faces	.195	.027	-.013	-.116	-.312	1	
7. Empathy for happy faces	**-.703****	**-.441***	-.240	**-.629****	**.795****	-.039	1

Table 11.

Variables	1.	2.	3.	4.	5.	6.	7.
Control Variable: Age and cognitive ability							
1. Emotional Abuse (CTQ)	1						
2. Emotional Neglect (CTQ)	**.725****	1					
3. Physical Neglect (CTQ)	**.493***	**.637****	1				
4. Total	**.888****	**.906****	**.719****	1			
5. Empathy for sad faces	**-.620****	-.371	-.093	**-.513****	1		
6. Empathy for neutral faces	.254	.071	-.039	-.170	-.216	1	
7. Empathy for happy faces	**-.676****	-.328	-.065	**-.502****	**.779****	.053	1

Partial Correlational analyses between the CTQ questionnaire and the behavior results of the Empathy task with variables age and cognitive ability controlled

Table 12. - correlational analyses between the CTQ questionnaire and the neural results of the Empathy task

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. Emotional Abuse (CTQ)	1														
2. Emotional Neglect (CTQ)	**.719****	1													
3. Physical neglect (CTQ)	**.517****	**.628****	1												
4. Total (CTQ)	**.836****	**.877****	**.740****	1											
5. Left insula sad and happy	.049	-.023	-.033	.046	1										
6. Left insula sad and neutral	.003	-.205	-.093	-.173	**.485****	1									
7. Left insula happy and neutral	.074	-.003	-.022	.093	**.892****	**.472****	1								
8. Left insula happy and neutral – second observation	.104	-.128	-.153	-.098	**,.467***	**.869****	**.463***	1							

9. Right insula sad and happy	.097	.265	-.051	.231	**,637****	.208	**.662****	.297	1						
10. Right insula sad and neutral	-.141	-.110	-.305	-.127	**,693****	.357	**.690****	.352	**.580****	1					
11. Amygdala sad and happy	.118	.253	-.024	.136	**,556****	.211	**.550****	.089	**,447***	**.442***	1				
12. Left Amygdala happy and neutral	.131	.285	.065	.159	**,682****	.245	**.688****	.184	**.553****	**.549****	**.929****	1			
13. Left Midcingulate cortex sad and happy	.269	.196	.075	.314	**,606****	.216	**.682****	.274	**.689****	**.384***	**.475****	**.488****	1		
14. Left Midcingulate cortex sad and neutral	.321	.167	.055	.297	**.603****	.366	**.606****	**.428***	**.646****	.250	**.449***	**.428***	**.894****	1	
15. Left Midcingulate cortex happy and neutral	.250	.207	.031	.298	**.592****	.209	**.678****	.260	**.706****	**.421***	**.506****	**.515****	**.978****	**.860****	1

Table 13. *Partial correlational analyses between the CTQ questionnaire and the neural results of the Empathy task with variables age and cognitive ability controlled*

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
Control Variable: Age and cognitive ability															
1. Emotional Abuse (CTQ)	1														
2. Emotional Neglect (CTQ)	**.725****	1													
3. Physical neglect (CTQ)	**.493***	**.637****	1												
4. Total (CTQ)	**.888****	**.906****	**.719****	1											
5. Left insula sad and happy	-.029	-.108	-.054	-.034	1										
6. Left insula sad and neutral	.071	-.103	-.050	-.035	**.564****	1									
7. Left insula happy and neutral	-.034	-.091	-.046	-.013	**.895****	**.517****	1								
8. Left insula happy and neutral – second observation	.165	-.034	-.060	.039	**.491****	**.886****	**.474***	1							
9. Right insula sad and happy	-.082	.014	-.217	-.021	**.711****	.347	**.707****	.360	1						
10. Right insula sad and neutral	.033	-.028	-.195	-.012	**.652****	**.438***	**.667****	.317	**.597****	1					
11. Amygdala sad and happy	-.070	.076	-.093	-.037	**.571****	.318	.620	.199	.380	**.545****	1				

12. Left Amygdala happy and neutral	-.028	.093	-.010	.026	**.689****	.339	**.739****	.253	**.496****	**.629****	**.945****	1			
13. Left Midcingulate cortex sad and happy	-.042	-.040	-.104	.006	.741**	.382	**.729****	**.399***	**.725****	**.445***	**.492****	**.551****	1		
14. Left Midcingulate cortex sad and neutral	.027	-.055	-.081	.008	**.691****	**.504****	**.606****	**.565****	**.647****	.294	.358	**.394***	**.909****	1	
15. Left Midcingulate cortex happy and neutral	-.122	-.092	-.161	-.058	**.696****	.335	**.716****	.341	**.726****	**.465***	**.523****	**.579****	**.972****	**.832****	1