Can people empathize with offenders and victims during violent scenes? Behavioral and brain correlates of affective and cognitive empathy considering victim vs. offender perspective using the Bochumer Affective and Cognitive Empathy Task (BACET).

Abstract

Empathy is defined as the capacity to resonate with others’ emotions and can be subdivided into affective and cognitive components. Few studies have focused on the role of perspective-taking within this ability. Utilizing the novel *Bochumer Affective and Cognitive Empathy Task* (BACET), the present study aims to determine the characteristics of specific empathy components, as well as the impact of offender vs. victim perspective-taking. A total of 21 male participants (mean age = 30.6) underwent functional magnetic resonance imaging (fMRI) while watching 60 videos showing two protagonists in neutral (n = 30) or violent interactions (n = 30) thereby adopting the perspective of the (later) offender or victim. Our data show that videos showing emotional (violent) content, compared to those with neutral content, were rated more emotionally negative and induced higher affective empathic involvement, particularly when adopting the victim's perspective compared to the offender’s point of view. The correct assignment of people´s appropriate emotion (cognitive empathy) was found to be more accurate and faster in the emotional condition relative to the neutral one. However, no significant differences in cognitive empathy performance were observed when comparing victim vs offender conditions. On a neural level, affective empathy processing, during emotional compared to neutral videos, was related to brain areas generally involved in social information processing, particularly in occipital, parietal, insular, and frontal regions. Cognitive aspects of empathy, relative to factual reasoning questions, were located in inferior occipital areas, fusiform gyrus, temporal pole, and frontal cortex. Neural differences were found depending on the perspective, i.e., empathizing with the victim, compared to the offender, during affective empathy activated parts of the right temporal lobe, whereas empathy towards the role of the offender revealed stronger activation in the right lingual gyrus. During cognitive empathy, empathy toward the victim, relative to the offender, enhanced activity of the right supramarginal and left precentral gyri. The opposite contrast did not show any significant differences. We conclude that the BACET can be a useful tool for further studying behavioral and neurobiological underpinnings of affective and cognitive empathy, especially in forensic populations since response patterns point to a significant impact of the observer's perspective.

Keywords: empathy, perspective-taking, aggression, fMRI, victim, offender.

1. Introduction

1.1. Affective/cognitive empathy and Theory of Mind

The continuous processing of complex and multifaced signals can be regarded as highly adaptive in the dynamics of human behavior. Having an idea about intentions, feelings, or beliefs of others can be very important not only in critical situations but it is also a crucial part of social interactions (Miller & Wallis, 2011). Among other constructs, empathy and Theory of Mind (ToM) are considered key features of social cognition (Van Overwalle & Baetens, 2009) and, therefore, play relevant roles in successful social communication. Empathy is commonly defined as the capacity to share and resonate with somebody's emotions, but with the explicit knowledge that the other person is the origin of this emotion (Decety & Jackson, 2004; de Vignemont & Singer, 2006; Singer & Lamm, 2009). Related to the previous definition and according to most authors, empathy can at least be subcategorized into an affective (or emotional) and a cognitive component (Shamay-Tsoory et al., 2009; Walter, 2012). While cognitive empathy targets the capability to identify and understand another's feelings and motivations (Frith & Frith, 2006; Lockwood et al., 2014), affective empathy is linked to the emotional resonance to others through observation or imagination of their experiences (Lockwood, 2016; Singer & Lamm, 2009; Walter, 2012). Another related feature of social cognition has been researched under the term ToM, describing an individual's competence to infer and reason about others' mental states, including desires, beliefs, knowledge, and intentions (cognitive ToM), but also emotions and feelings (affective ToM), which are different from one's own (Frith, & Frith, 2005,2012; Mitchell, 2005; Shamay-Tsoory et al., 2009). An overview of the described concepts of social cognition can be found in Figure 1 which also points to a potential overlap between cognitive empathy and affective ToM (for detailed reviews, see Molenberghs et al., 2016; Shamay-Tsoory et al., 2007; Walter, 2012).

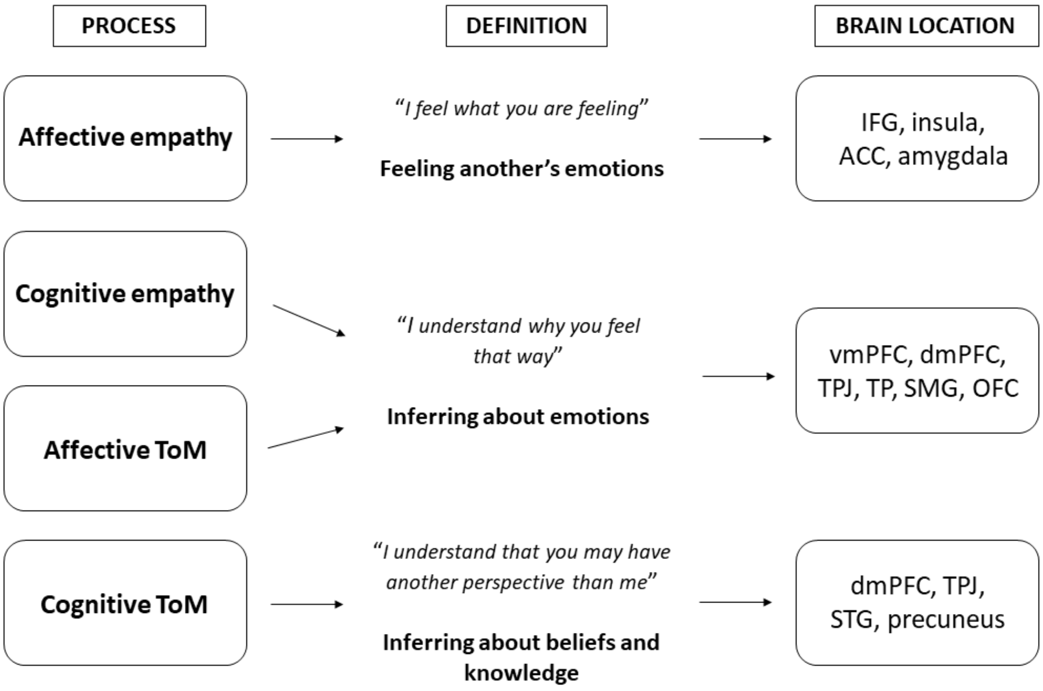

Figure 1. Definition and brain correlates of empathy and theory of mind and its subcategories. *Note*: ToM = Theory of Mind, IFG = inferior frontal gyrus, ACC = anterior midcingulate cortex, vmPFC = ventromedial prefrontal cortex, dmPFC = dorsomedial prefrontal cortex, TPJ= temporo-parietal junction, TP = temporal poles, SMG = supramarginal gyri, OFC = orbitofrontal cortex, STG = superior temporal gyrus.

1.2. Neural correlates of empathy and Theory of Mind

Early neuroscientific investigations targeting empathy in the domain of pain found that the same neural network is activated during the receipt of pain and also when witnessing others experiencing painful stimuli (De Vignemont & Singer, 2006; Decety & Jackson, 2004; Decety & Lamm, 2006; Singer et al., 2004). This so-called '*pain matrix'* is composed of the anterior insula (AI) and the anterior midcingulate cortex (aMCC) (Bzdok et al., 2012; Fan et al., 2011; Lamm et al., 2011). Several meta-analyses have concluded that the broad empathy network includes the dorsomedial prefrontal cortex (dmPFC), AI, anterior cingulate cortex (ACC), MCC, inferior frontal gyrus (IFG), postcentral gyrus, parietal cortex, amygdala, and brainstem, among others (Bzdok et al., 2012; Kogler et al., 2020; Timmers et al., 2018). Taking into account specific components of empathy the anterior dmPFC, ventromedial prefrontal cortex (vmPFC), supramarginal gyrus (SMG), temporo-parietal junction (TPJ), aMCC, orbitofrontal cortices (OFC), and medial temporal lobe (MTL) are reported to be activated during cognitive empathy, while AI, IFG, posterior part of the dmPFC, amygdala, and ACC are identified to be particularly involved in affective empathy (Molnar-Szakacs, 2011; Kogler et al., 2020; Shamay-Tsoory, 2011; Walter, 2012). Core regions of the neural ToM network include dmPFC, TPJ, superior temporal gyrus (STG), and temporal poles (TP) (Bzdok et al., 2012; Dodell-Feder et al., 2011; Molenberghs et al., 2016; Schurz et al., 2014; Van Overwalle & Baetens, 2009). Affective ToM shows greater activation in vmPFC, OFC, temporal poles, and middle temporal gyrus, while cognitive ToM elicited higher activation in dmPFC, TPJ, and precuneus, among others (Molenberghs et al., 2016; Walter, 2012), see Figure 1.

Among the tasks that assess empathy and ToM, the socio-affective video task (SoVT) is a well-known paradigm in which video clips are presented representing people in high and low emotion activities and the participants are asked to rate how they feel and how they empathize with the represented person (Klimecki et al., 2014). Likewise, the EmpaToM paradigm measures empathy by showing realistic videos that can either be emotionally negative or neutral, as well as ToM which is assessed through questions that involve inferring the mental state of the narrator or physical facts (factual reasoning as a control condition; Kanske et al., 2015).

1.3. Neural correlates of perspective-taking in violent scenarios

Due to the growing global interest in brain alterations in response to exposure to violent media, neuroscientific paradigms of empathic processing were expanded to focus on aggressive and violent behavior. Regarding neural activity underlying violent scenes, it has been found that basic exposure to real scenes of aggression (e.g. street fights, stadium violence) showed a main activation effect in bilateral OFC, IFG, ACC, posterior cingulate cortex, middle temporal gyri, and middle occipital gyri (Strenziok et al., 2011). Most previous studies used experimental settings in which participants were required to act along with their moral values, but only a few investigations have delved into the perpetrator's perspective. Results of perspective-taking experiments have shown that people adopting the role of an offender are more likely to approve aggressive behaviors than people under the victim's perspective (Rascle et al., 2010).

It is important to highlight that studies investigating empathy have barely addressed the contribution of perspective at the brain level. In Decety and Porges (2011), participants were asked to adopt the viewpoint of a specific person in a video clip which could be either an individual hurting or helping another person. The first condition involved increased activity in the dorsolateral prefrontal cortex (dlPFC), ventrolateral PFC, and IFG, as well as deactivation of medial OFC. When taking the perspective of helping, enhanced activation in dlPFC, ventral striatum, as well as TPJ, was found. Imagining oneself as the victim, as opposed to the aggressor, activated brain regions related to the pain matrix (including the insula, ACC, SMA, and somatosensory cortex), the preparation of defensive behaviors (such as motor cortex, aMCC, and visual regions including cuneus and calcarine sulcus) and fear processing (amygdala, Decety & Porges, 2011). In Nummenmaa et al. (2008), during the presentation of aversive (attack scenes) and neutral scenes, participants were asked to empathize with a specific target person (attacker, victim, or a person involved in non-emotional activities). While no stronger activations were found for empathy towards aggressors than victims, the opposite contrast showed significant activations in the left precuneus, right fusiform gyrus, insula, and bilaterally in the inferior parietal lobe (IPL). These results were not due to the higher attention paid to the victim compared to the aggressor since the eye-tracker results did not show increased attention toward victims (Nummenmaa et al., 2008). Another study on empathic responses in the context of offender vs. victim perspectives revealed that focusing on an aggressor during a hostile conversation video triggered more activation in the left ACC, STS, amygdala, right middle occipital gyrus, and bilateral occipital pole, while no regions showed higher responses when the focus was on the victim (Van den Stock et al., 2015).

1.4. Relevance of the present study

In summary, the previous studies displayed heterogeneous findings regarding the neurobiological correlates of empathy in the context of offender vs. victim perspectives, most likely due to several methodological issues. Among them, studies differed in the underlying stimulus material (pictures vs. video clips) as well as in the way the switch of the participants' perspective was implemented within the task design. For instance, the main focus of the study from Van den Stock et al. (2015) was associated with the switch of attention towards a victim or offender rather than the investigation of empathetic responses under the influence of different perspectives. Moreover, none of these studies clearly differentiated between aspects of cognitive and affective empathy that, however, should be regarded as separate entities. We are aware of one study, Nummenmaa et al. (2008), which differentiated between empathy components, but this study used neutral scenes for cognitive empathy. In an attempt to overcome most of these limitations, the current study intends to investigate the neural correlates of both affective and cognitive empathy adopting the role of a victim and an offender in a violent context, introducing a new experimental paradigm called *Bochumer Affective and Cognitive Empathy Task* (BACET). The BACET is methodologically based on the EmpaTom paradigm from Kanske et al. (2015). While the previous authors focused on the ecological assessment of affective empathy and ToM within the same individuals during emotional short episodes, the BACET is unique in that it is designed to simultaneously measure both affective and cognitive aspects of empathy as well as neural responses to differences in perspective-taking within the same individuals, using violent videos as stimuli in which two actors are clearly allocable as victim and offender. Stimuli consisted of different short movie scenes that were only manipulated across conditions in terms of emotional valence and perspective focus. See Figure 2 for a summary of the measures applied in the experiment.

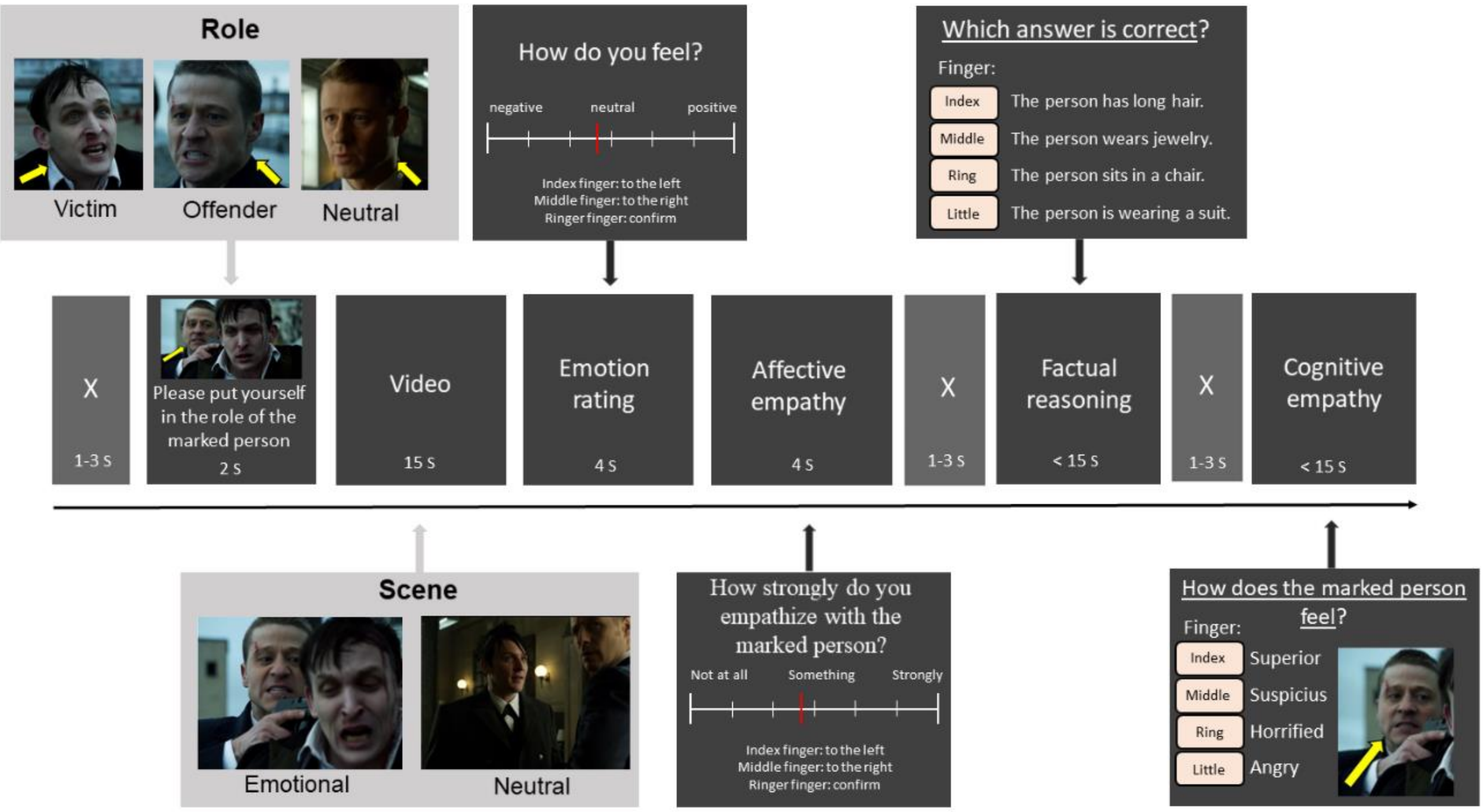

Figure 2. BACET trial design. After a cue indicating which person to focus on, a video is shown for 15 seconds. Participants are not explicitly instructed to focus on a "victim" or "offender", but the term "marked person" along with the pictures are used. The different experimental conditions are represented in lighter grey boxes with perspective (under role) and emotion (under scene) factors. All emotional videos correspond to negative

violent scenes with clear victim and offender roles, while the neutral videos represent a neutral interaction between two people. Subsequently, participants have to answer several questions about feelings (emotion rating), affective and cognitive empathy, and factual reasoning.

1.5. Hypotheses

We expected to find differences between cognitive and affective empathy both at behavioral and brain levels within the same pattern of activation reported in previous literature.

1.5.1. Behavioral hypotheses

a) Looking at the emotion rating, we expected that emotional videos would be rated lower (more negatively) compared to neutral videos (emotional factor), as well as lower ratings for victims compared to offenders' perspective but only in the emotional condition (perspective factor). b) Related to the affective empathy question, we expected that empathy toward victims in emotional conditions would be higher compared to both offenders in emotional scenes (perspective factor) and compared to neutral conditions (emotional factor). c) Regarding the factual reasoning and cognitive empathy questions, we expected better performance in emotional compared to neutral conditions (emotional factor) and no differences comparing victim vs offender (perspective factor).

1.5.2. Neural hypotheses

According to the previously reported studies, a) we hypothesized that affective empathy during emotional videos would significantly activate regions usually related to affective empathy such as AI, IFG, amygdala, ACC, and the posterior part of the dmPFC compared to the neutral videos. b) We furthermore expected the anterior dmPFC, vmPFC, OFC, MTL, TPJ, and SMG would show higher activation during cognitive empathy compared to the control condition (factual reasoning questions). c) Regarding the perspective factor and based on a few previous studies (Nummenmaa et al., 2008; Van den Stock et al., 2015), we expected that taking the perspective of a victim would be likely to produce a stronger response in the fusiform gyrus, precuneus gyrus, IPL, and insula, while adopting the role of the offender may be associated with higher activation in middle occipital gyrus, occipital pole, STS, ACC, and amygdala in emotional conditions.

2. Material and methods

2.1. Participants

Twenty-three male healthy volunteers (age mean 30.59, see Table 1) were recruited through the Internet and posting advertisements.

Table 1. Characteristics of study participants.

Characteristics	
Age. Years, mean (*SD*), range	30.59(6.07), 21-44
Handedness (R/L/missing)	(19/2/2)
Familiar status. *n*. (%)	
Single	12 (52.2)
Married	10 (43.5)
No data	1 (4.3)
Educational level. No. (%)	
Not graduated	1 (4.3)
Secondary school	3 (13.0)
High school	11 (47.8)
Bachelor degree	4 (17.4)
Master degree	3 (13.0)
No data	1 (4.3)
Years of education, mean (*SD*), range	17.47(3.72), 10-25
MWT-IQ estimates, mean (*SD*), range	107.36(13.85), 91-145
SCL-90-R-GSI, mean (*SD*), range	52.63(8.94), 40-80

Note: R = right, L = left, No = number, MWT = Multiple-choice Vocabulary Test, IQ = Intelligence Quotient, SCL-90-R= Symptom Check List-90-R, GSI = Global Severity Index. Secondary school corresponds to *Realschule* in the German educational system and high school corresponds to *Gymnasium* in the German educational system.

Exclusion criteria were neurological or acute psychiatric disorders, acute episodes of alcohol or drug abuse/dependence, as well as past dependencies. One participant was removed from the analysis due to head movements of more than 3 mm, and another participant was excluded due to signal artifacts, resulting in corrupted image data. The final study sample consisted of 21 volunteers. The study was approved by the Ethics Committee of the Medical Faculty of the Ruhr-University Bochum, Germany following the guidelines of the Declaration of Helsinki. All participants gave written informed consent to the study protocol before taking part.

2.2. Assessments

All participants completed the self-administration questionnaire *Symptom Check List-90-R* (SCL-90-R; Deragotis, 1986). The SCL-90-R global severity index (GSI) was used to assess for general mental stress. This test has been validated for the German healthy population, classified as a good instrument for assessing psychological status and screening for psychiatric disorders (Smith et al., 2000). Drug abuse/dependence was assessed using the related section of the *Structured Clinical Interview* (SKID-IV) for the *Diagnostic Statistical Manual IV* (DSM-IV), applied by a trained research associate. Verbal intelligence was estimated using the *Multiple-choice vocabulary test* (Mehrfach Wortschatz Test, MWT; Lehrl, 2005) and all assessments were implemented through experienced researchers who were trained to use these instruments.

2.3. BACET (Bochumer Affective and Cognitive Empathy Task)

Design. Initially, participants received a short verbal introduction about the upcoming fMRI assessment and then were positioned inside the MR bore. Each experimental trial consisted of a sequence of stimuli and questions (see Figure 2) and started with the presentation of a fixation cross with a random duration between 1-3 seconds. Afterward, a screenshot indicated the following clip and requested participants to keep their attention focused on the person marked with a yellow arrow without an explicit indication of "victim" or "offender". After participant's confirmation, a short video was displayed for 15 seconds (affective empathy phase). The videos differed in terms of emotional valence (30 emotionally neutral vs. 30 emotional videos) as well as perspective (15 emotional offender-focused trials, and 15 emotional victim-focused trials). After each clip, participants were asked to rate how they felt (emotion rating) and how strongly they empathized with the person they focused on (affective empathy rating). Both ratings were applied by moving a bar on the screen via a button press (index finger = move bar to the left, middle finger = move bar to the right, ring finger = lock rating) to the appropriate position, controlled by the right hand using a four-button MRI-ready response keyboard (Lumitouch, Photon Control Inc., Canada). Using a randomized presentation order, the next fixation cross (1-3 seconds) was followed up by either cognitive empathy or factual reasoning (FR) condition (equally distributed). In case of the latter, participants were requested to remember facts from the previously shown video clip assessed by choosing the right answer out of four options. Finally, the next fixation cross (1-3 seconds) was followed up by the other multiple-choice question, in this case related to cognitive

empathy. Accordingly, participants were asked to indicate how the highlighted person was feeling during the clip by choosing a term out of a list of four emotional words (cognitive empathy phase). Both multiple-choice questions (FR and cognitive empathy conditions) were limited to a trial duration of 15 seconds before time ran out.
Once the participants confirmed all instructions and started the paradigm, two trials were administered to familiarize them with the task. Exemplary depictions of images, video screenshots, questions, and keyboard finger allocations can be found in Figure 2. Stimuli were displayed using the software Presentation (Neurobehavioral Systems, Inc, version 11.0) on MRI-ready LCD-goggles (VisuaStim, Digital, Resonance Technology Inc., Northridge, CA). Finally, at the end of the scanning session, participants completed a questionnaire indicating if any of the presented movie clips were recognized, to control for the familiarity effect.

Stimuli. Video stimuli consisted of movie clips with a duration of 15 seconds each, showing two actors. Clips differed in terms of emotional valence, with 30 being violent and 30 being neutral scenes. During emotional videos, two persons were shown in a violent and negative interaction in which one of them was classified as an offender who causes physical harm to a second person classified as a victim. Each emotional video was matched with a neutral video consisting of the same actors without a specific role in a non-emotional context.

Videos were taken from several series provided by the streaming platforms *Amazon Prime* and *Netflix*. The raw footage was edited into 15-second movie clips (800x600 pixels; 25 frames/second) using the software *Final Cut Pro X* and the audio signal was removed. Stimuli were presented in a semi-randomized order to preclude the sequential presentation of cohesive violent and neutral videos. During cognitive empathy ratings, a representative screenshot from the according video was displayed on the left part of the monitor, while on the right side, the question with its four possible options was presented.

2.4. Image parameters and processing

Brain images were acquired using a 3T Philips Achiva Scanner, equipped with a 32-channel head coil. Structural images were acquired using a T1-weighted sequence (slices = 220; TR = 8.2 ms; TE = 3.8 ms; flip angle = 8º; FOV = 240 mm; matrix size = 188 x 220 mm), yielding a final voxel size of 1 x 1 x 1 mm. For functional imaging, a T2*-weighted echo-planar imaging (EPI) sequence was used (TR = 2400 ms; TE = 30 ms, flip angle = 80º, FOV= 258 mm; matrix size = 112 x 109 mm). Thirty-eight transverse slices were acquired encompassing the whole brain with a voxel size of 2.3 x 2.3 x 3 mm. The first five volumes were discarded from further analysis to account for T1 relaxation effects. Functional volumes were preprocessed using Statistical Parametric Mapping Software (SPM12, Welcome Centre for Human Neuroimaging, London, UK, https://www.fil.ion.ucl.ac.uk/spm/software/ spm12/). All volumes were (1) slice timing corrected using the middle slice as a reference, (2) realigned and unwarped, using an interpolation of 4th degree B-spline, (3) co-registered to the according to T1 image using rigid transformation and normalized mutual information, (4) spatially normalized into Montreal Neurological Institute (MNI) space utilizing the individual T1 image, and (5) smoothed with an isotropic Gaussian full width half maximum kernel of 8 mm. Furthermore, WFU_PickAtas toolbox (https://www.nitrc.org/projects/wfu_pickatlas/) implemented in SPM12 and Automated Anatomical Labeling (AAL) atlas were used to determine neuroanatomic locations.

2.5. Data analysis

2.5.1. Behavioral data analysis

Statistical analyses were carried out using SPSS (IBM SPSS Statistics 20.0, Chicago, IL) for Windows. Affective variables (emotion and affective empathy ratings), as well as response times (RTs) during ratings, were transformed into *z-scores*. FR and cognitive empathy performance scores were calculated as the difference between the total amounts of correct vs. incorrect responses. Statistical comparisons between conditions were applied by means of one-sample t-tests (or Wilcoxon tests if the precondition of normally distributed data was violated). All statistical analyses were performed two-tailed $p < .05$ level of significance.

2.5.2. fMRI data analysis

Functional analyses were performed using SPM12. Similar to the methods described in Kanske et al. (2015), for each type of video and question (including rating periods), onsets and durations were modeled. In case of emotional events, separate regressors for victim and offender conditions were built. Although we have no victim vs. offender distinction in neutral events, we nonetheless built separate regressors in this condition for corresponding victim vs. offender actors (matched to the respective emotional event).

This procedure enabled us to keep constant the amount of trials between conditions. Moreover, the use of the same actors (without a specific role) in similar environments in the neutral condition targets the minimization of confounding influences. Accordingly, for first-level analysis, the following variables were included in the design matrix, separately for affective empathy videos, cognitive empathy questions, and FR questions: emotional victim, emotional offender, corresponding neutral (victim), corresponding neutral (offender), resulting in 12 regressors. For reasons of clarity, we forgo detailed descriptions of the neutral conditions in the following paragraphs and simply use the term "neutral". Signals of other events like fixation cross phases were captured by implicit baseline regressor. Event-related responses were convolved with the canonical hemodynamic response function (HRF) with no derivatives. A high pass filter of 128s was applied.

On the second level, the following effects were investigated using one-sample *t*-tests: within-group main effect of affective empathy (emotional vs. neutral videos); within-group effects of perspective (emotional victim videos vs. neutral videos, and emotional offender videos vs. neutral videos); within-group main effect of cognitive empathy (CE questions vs FR questions). A one-way ANOVA was calculated to analyze the main effect of perspective on affective empathy using the contrasts emotional victim videos > neutral videos vs. emotional offender videos > neutral videos. To examine the effect of perspective on cognitive empathy, separate contrasts were created between CE and FR for each perspective (victim and offender), i.e., (CE emotional victim question > FR emotional victim question) vs. (CE neutral question > FR neutral question), and (CE emotional offender question > FR emotional offender question) vs. (CE neutral question> FR neutral question). A one-way ANOVA was calculated to analyze the main effect of perspective on cognitive empathy using the mentioned contrasts (adjusted cognitive empathy emotional victim vs adjusted cognitive empathy emotional offender). Results were considered significant when surviving a height threshold of $p < .05$ at voxel-level corrected for multiple comparisons according to the family-wise error (FWE) to minimize false positive results. Concerning the emotion and perspective interaction analyses, we considered significant results on an uncorrected level of $p < .001$ at voxel-level that survive at $p < .05$ FWE at cluster-level due to the more exploratory characteristic of these analyses and the small sample size. To explore the potential relationship between behavioral performance and brain activity during emotion and empathy processing, three separate multiple regression analyses were performed for the main contrast of affective empathy including emotion rating and affective empathy rating as covariates, and for the main contrast of cognitive empathy including cognitive empathy rating as a covariate.

3. Results

3.1. Behavioral results

Emotion ratings. Analysis of the emotion ratings indicated lower valence values (z-transformed) during emotional as compared to neutral videos (*t*(20) = -11.94, *p* < .001) in general. During emotional videos, results revealed lower ratings for victim as compared to offender conditions (*t*(20) = -4.37, *p* < .001). Lower valence values correspond to a more negative emotional state of the participants. There were no RT differences regarding emotion ratings neither between emotional and neutral videos (*t*(20) = .44, *p* = .664) nor between victim and offender videos (*t*(20) = -.32, *p* = .749). For further details, see Figure 3 and Supplementary Table S1.

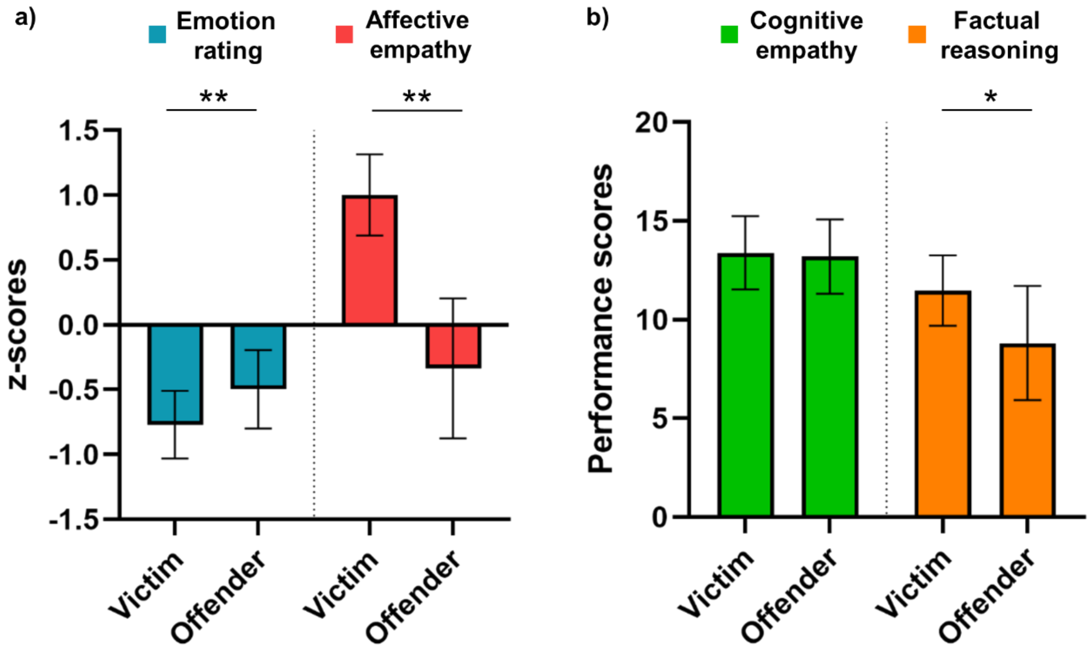

Figure 3. Behavioral differences between victim and offender scores. a) Emotion rating: how do you feel? Affective empathy: how strongly do you empathize with …? b) Cognitive empathy: how does the person feel? Factual reasoning: which answer is correct? Significant differences are represented by asterisks: * < 0.01, ** < 0.001. Error bars represent standard deviations.

Affective Empathy ratings. Analysis of affective empathy ratings revealed significantly higher scores for emotional as compared to neutral videos ($t(20) = 5.86$, $p < .001$). Within the emotional condition, the comparison between both perspectives resulted in increased affective empathy ratings to victim as compared to offender videos ($t(20) = 8.63$, $p < .001$), whereas increased values are indicative of more pronounced affective empathy processing. While participants showed faster responses to affective empathy questions in neutral as compared to emotional conditions ($t(20) = 2.42$, $p = .025$), no significant RT differences between victim and offender conditions were found ($t(20) = -.58$, $p = .569$). For further details, see Figure 3 and Supplementary Table S1.

Cognitive empathy and factual reasoning performance. There were significant differences between emotional and neutral conditions in cognitive empathy performance (z = -4.02, $p < .001$; more accurate performance in emotional condition) and RTs ($t(20) = -4.76$, $p < .001$; faster responses in emotional condition), as well as factual reasoning performance ($t(20) = -5.83$, $p < .001$; more correct responses in neutral condition) and RTs ($t(20) = -3.60$, $p = .002$; faster responses in neutral condition), see Supplementary Table S1 for further details. No differences between victim and offender videos were found in cognitive empathy performance (z = -.58, $p = 569$) or RTs ($t(20) = -.58$, $p = .564$). Participants showed more correct responses in factual reasoning during victim vs. offender conditions ($t(20) = -3.14$, $p = .002$), and responded faster ($t(20) = -6.46$, $p < .001$), see Figure 3 and Supplementary Table S1.

3.2. fMRI results.

3.2.1. Affective empathy.

To assess the neural correlates of affective empathy, we compared emotional and neutral videos. The contrast negative emotional > neutral showed BOLD signal responses in a network comprising bilateral superior occipital, and superior parietal lobules, as well as increased activity in bilateral precentral gyri, left SMG, bilateral inferior frontal regions, left middle cingulate cortex, right insula, and parts of the cerebellum (see Supplementary Figure S1 and Table S2). The opposite contrast did not show any significant activations.

As a next step, we assessed perspective taking during negative emotional videos (victim > offender). Results revealed increased activation in the right middle (MNI coordinate: x = 52, y = 4, z = -22) and superior temporal (MNI coordinate: x = 60, y = -24, z = -2) gyri.

The opposite contrast resulted in a marginal significant activation in the right lingual gyrus (MNI coordinate: x = 14, y = -78, z = 4). For a detailed overview see Supplementary Table S2 and Figures 4 and 5.

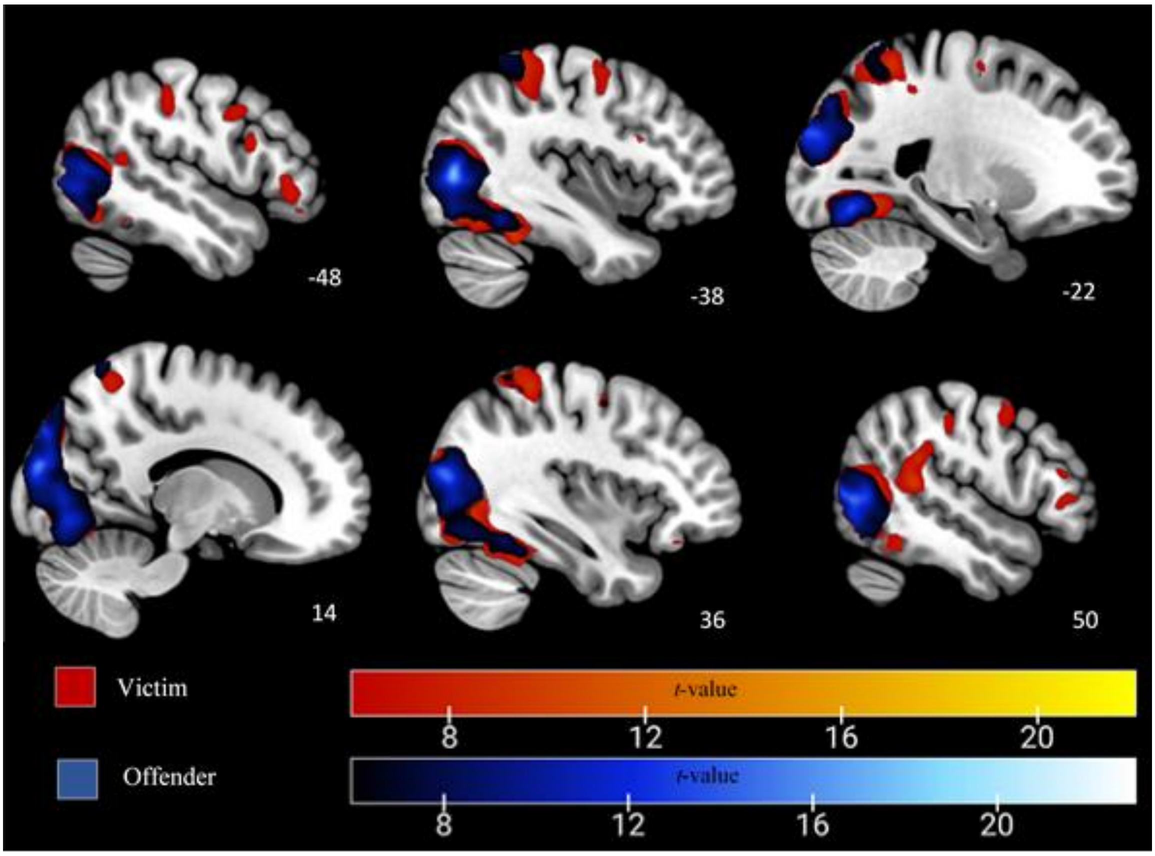

Figure 4. BOLD activations related to the contrasts affective empathy emotional victim > neutral (red), and affective empathy emotional offender > neutral (blue) showing overlapping areas. For further details, see Supplementary Table S2. The statistical threshold maps are set to $P < .05$, FWE corrected at the voxel level. *Note*: the figure has been created with the MRIcroGL 1.2 software (https://www.nitrc.org/projects/mricro), and the values of the x-coordinates in the figure correspond to the standard 2D slice coordinate system of the software.

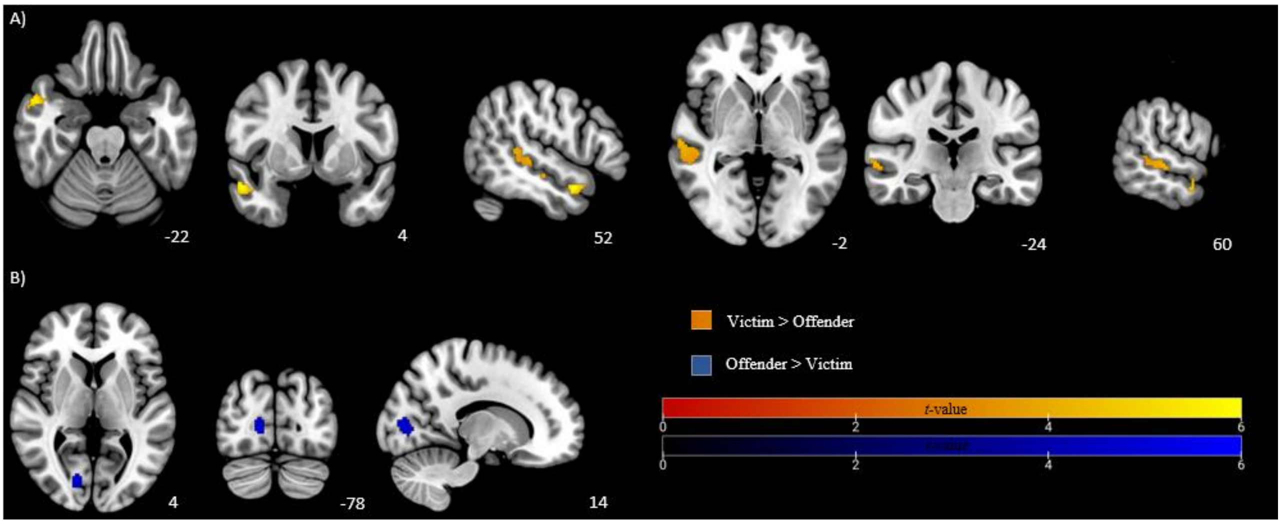

Figure 5. Main effect of perspective in affective empathy. (A) Affective empathy victim > affective empathy offender increased activation in the (posterior) superior temporal sulcus (pSTS) (B) Affective empathy offender > affective empathy victim increased activation in the right lingual gyrus. These statistical threshold maps are set to $p < .001$ uncorrected at voxel-level and $p < .05$ FWE corrected at cluster-level. *Note*: the figure has been created with the MRIcroGL 1.2 software (https://www.nitrc.org/projects/mricro), and the values in the figure correspond to the standard 2D slice coordinate system of the software.

3.2.2. Cognitive empathy.

To investigate the related effects of cognitive empathy, neural responses during the performance of cognitive empathy questions were compared to those during FR questions, irrespective of the emotion valence of the previously presented videos (cognitive empathy emotional + cognitive empathy neutral > FR emotional + FR neutral). Accordingly, activations in a network including left cuneus, bilateral fusiform gyri, bilateral inferior and superior frontal gyri, and middle TP, among others, were found. The opposite contrast showed increased activation in the right calcarine and angular gyri, left middle occipital gyrus, and left parahippocampal gyrus. For a detailed view see Figure S2 and Supplementary Table S2.

Comparisons including perspective in cognitive empathy (comparing cognitive empathy victim > cognitive empathy offender) revealed higher activation in the right SMG (MNI coordinate: x = 60, y = -44, z = 32) as well as left precentral gyrus (MNI coordinate: x =

-52, y = 4, z = 46), while the opposite comparison did not show any significant activation, for further details see Figure 6 and Supplementary Table S2.

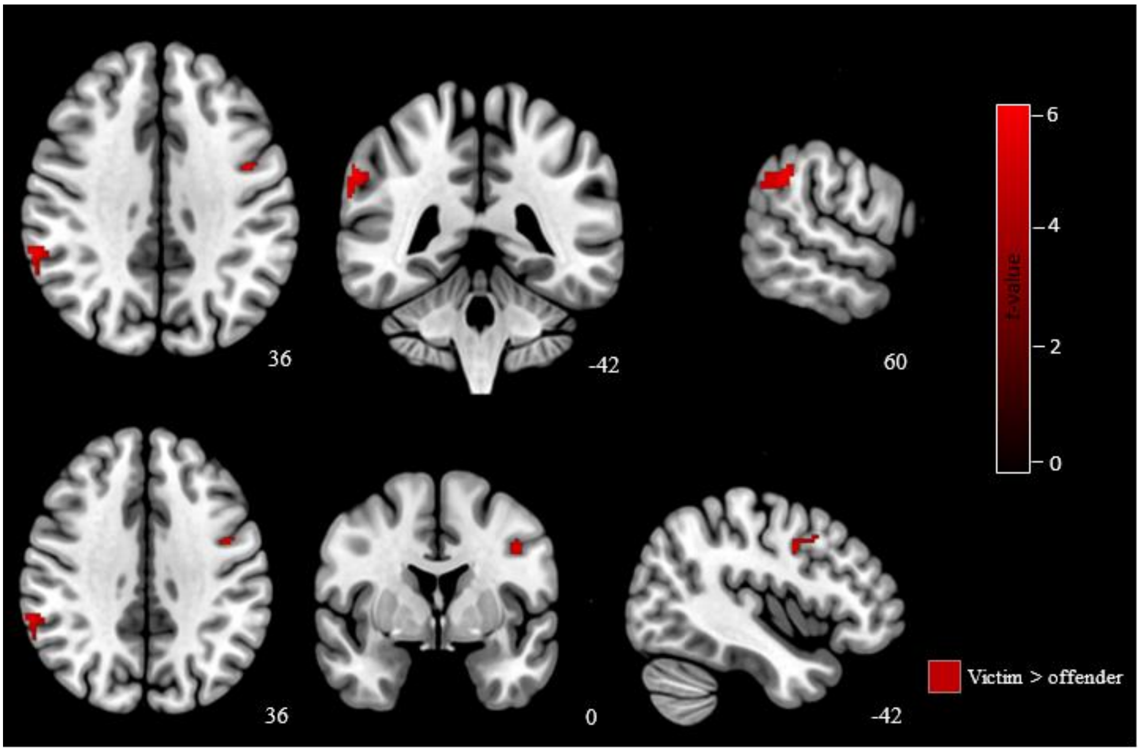

Figure 6. Cognitive empathy emotional victim > cognitive empathy emotional offender increased activation in the right supramarginal gyrus and left precentral gyrus. The opposite contrast did not show any significant activation. These statistical threshold maps are set to $p < .001$ uncorrected at voxel-level and $p < .05$ FWE corrected at cluster-level. *Note*: the figure has been created with the MRIcroGL 1.2 software (https://www.nitrc.org/projects/mricro), and the values in the figure correspond to the standard 2D slice coordinate system of the software.

3.3. Regression results

During the processing of emotional video content, emotion ratings were negatively correlated with brain activity located in the right precuneus (MNI coordinate: x = 16, y = -44, z = 42) and left postcentral gyrus (MNI coordinate: x = -46, y = -20, z = 60), see Figure 7 and Supplementary Table S3 for further details.

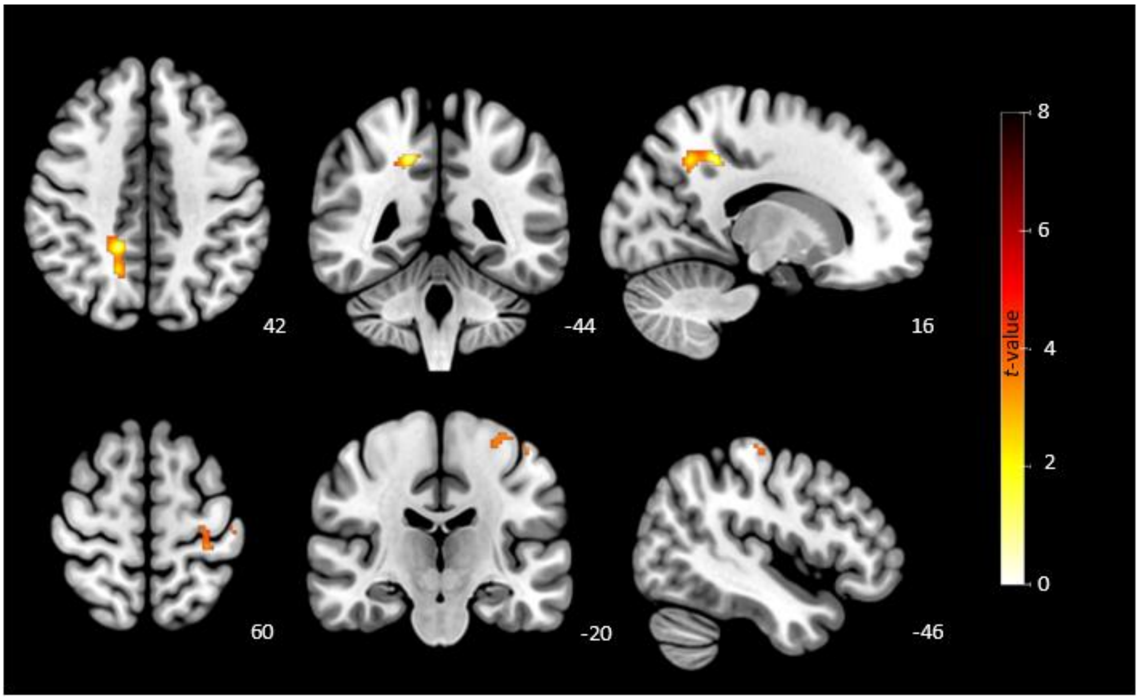

Figure 7. The negative relationship between emotion rating and brain activity during affective empathy is located in the right precuneus and left postcentral gyrus. These statistical threshold maps are set to $p < .001$ uncorrected at voxel-level and $p < .05$ FWE corrected at cluster-level. *Note*: the figure has been created with the MRIcroGL 1.2 software (https://www.nitrc.org/projects/mricro), and the values in the figure correspond to the standard 2D slice coordinate system of the software.

Neither affective nor cognitive ratings showed any significant association with brain activity.

4. Discussion

The present study presents and uses the novel BACET paradigm to assess both behavioral markers and brain correlates associated with affective and cognitive empathy within the same individuals adopting victim and offender perspectives.

4.1. Affective empathy

As expected and consistent with previous research (Kanske et al., 2015; Nummenmaa et al., 2008), emotional conditions provoked higher and more negative emotional valence ratings compared to neutral videos. When analyzing the brain activity underlying affective empathy during emotional vs. neutral videos, we detected significant brain activation in the bilateral occipital, superior parietal gyri, SMG, bilateral IFG, and AI.

These neural responses are largely in line with the findings of Kanske et al. (2015) regarding empathy processing.

In particular, occipital activations are increased during the processing of violent and unpleasant stimuli (Aldhafeeri et al., 2012; Strenziok et al., 2011; Nummenmaa et al., 2008). Activation observed in SMG, superior parietal lobe, and IFG might reflect involvement in the processing of social cues (Lawrence et al., 2006) that enable resonating with the agent. Kanske et al. (2015) concluded that the activation of SMG during empathy is associated with the self-other distinction of emotional states. Previous research on affective empathy has consistently shown activation in bilateral IFG and bilaterally precentral gyri when observing others in emotional and painful situations (Bzdok et al., 2012; Kanske et al., 2015; Kogler et al., 2020; Shamay-Tsoory, 2011). The IFG is crucial for emotional perspective-taking (Schulte-Rüther et al., 2007; Shamay-Tsoory, 2011), evaluation (Carr et al., 2003), and regulation (Morawetz et al., 2017). Similarly, the precentral gyrus is involved in perceiving two-person aggressive interactions (Van den Stock et al., 2015), and related to affective empathy during social scenes when detecting the change in an emotional state (Hooket et al., 2008). Finally, the right AI has been identified as a core region for empathy (Bzdok et al., 2012; Fan et al., 2011), particularly in experiencing pain and witnessing others' suffering (Fan et al., 2011; Lamm et al., 2011; Kogler et al., 2020; Timmers et al., 2018).

4.1.1. Affective empathy by adopting the victim's perspective

The present findings demonstrate more negative emotion when focusing on victims compared to offenders during emotional videos. This aligns with the interaction effect found by Nummenmaa et al. (2008), indicating that the emotional response pattern depends on the perspective taken. The authors concluded that adopting the perspective of attackers may lead to anger while empathizing with victims is likely related to fear. However, such conclusion cannot be confirmed by the present study, since types of emotion were not differentiated.

When empathizing with the victim, compared to the offender, activation was detected in the right middle and superior temporal gyri, particularly in the right TP region. This region is often associated with socio-emotional processing including emotional face recognition (Whitehead et al., 2009), imitation and generation of emotions (Carr et al., 2003), memory retrieval (Burianova et al., 2010), social cognition (Bzdok et al., 2013) and especially inference of the emotional states of others (Frith and Frith, 2003; Völlm et al., 2006). In the review carried out by Frith and Frith (2003), TP was described as a crucial part of the “mentalizing” brain to create a rich semantic and emotional meaning for the situation being processed. This suggests that in order to understand the behavior of another person we imagine ourselves in the other’s situation based on similar experiences (Gallagher & Frith, 2004).

Interestingly, the absence of right TP activation during offender focus may suggest difficulties for our non-violent study population in adopting the perspective of the attacker, given their limited experiences in such contexts. On the other hand, the activation of the right TP during victim focus could indicate the involvement of this region in making inferences about emotional and mental states while watching violent scenes, likely through interpreting the scene based on the participant's own social scripts. Although the participants may have lacked experience in the victim's role as well, they might have found it easier to relate to a more realistic role within the context of violent interaction.

Our findings complement the only known study that found significant activation while empathizing with victims over offenders. While Nummenmaa et al. (2008) reported activations in precuneus, fusiform gyrus, right insula, and IPL, our study mainly found significant activation in the temporal lobe. These differences may stem from variations in task characteristics between the studies. In the aforementioned study, participants were presented with static photographs, while in our study, volunteers watched realistic videos depicting violent interactions. The dynamic nature of our stimuli might provide a more ecologically valid representation of real-life scenarios and elicit a richer mentalizing process. The involvement of TP may be related to a greater ability to relate to social scripts and more significantly activate mentalizing skills.

4.1.2. Affective empathy by adopting the offender’s perspective

Our study revealed significant activation in the right lingual gyrus when empathizing with offenders, compared to victims, which aligns with the findings from Van den Stock et al. (2015). In their study, they observed increased activation in occipital regions, among other regions, when focused on the aggressor, compared to the victim, while watching violent videos. The involvement of the occipital lobe in both studies might be related to processing visual information related to emotional cues. On the other hand, lingual gyrus activation has been associated with the processing of emotional facial expressions (Fusar-

Poli et al., 2009; Nomi et al., 2008). Right occipital activation is also activated during empathy and ToM performance (De Greck et al., 2012; Raposo et al., 2011; Völlm et al., 2006). Van den Stock et al. (2015) concluded that angry body language compared to fearful body language increased the activations in these areas suggesting that the neural processing of emotional interactions heavily relies on the emotional cues transmitted by the focused agent.

4.2. Cognitive empathy

At the behavioral level, cognitive performance was moderately associated with emotion, indicating more accurate recognition of mental states during emotional compared to neutral conditions. Similar results were reported by Kanske et al. (2015), where cognitive performance was found to be enhanced relative to FR performance in emotional conditions.

Consistent with our expectations, there were no significant differences in cognitive empathy performance comparing victim and offender conditions. However, we did observe reduced performance during factual reasoning in the emotional offender condition. Participants were equally good at guessing how the victim and offender felt during the violent interactions but did not perceive the physical characteristics of the offender as correctly. During this perspective-taking exercise, the salience detection system may be more active during the victim scenes due to significantly greater impact in order to signal potential threats and orient attention to significant sensory events (Legrain et al., 2011). Thus, this reduced performance may stem from decreased attention to the offender's figure, although this interpretation lacks empirical support without a direct measure of attention, such as eye-tracking. It is worth noting that previous studies (Nummenmaa et al., 2008; Van den Stock et al., 2015) did not find differences in the focus of attention between victims and offenders, which challenges this explanation.

In the BACET, the comparison between cognitive empathy over factual reasoning questions corroborated previous research reporting neural activation in regions such as cuneus, fusiform gyri, IFG (also referred to in the literature as ventrolateral PFC), superior frontal gyri (also referred as dorsolateral PFC), TP, SMA, and cerebellum (Eres et al., 2015; Kogler et al., 2020). Similar activations in areas such as STS, superior frontal gyrus, TP, and cerebellum were reported by Kanske et al. (2015) in the EmpaToM task involving ToM questions.

In our task, cognitive empathy was associated with increased activation in PFC. The dmPFC has been described as the core area of cognitive empathy (Kogler et al., 2020), associated with perspective-taking (D’argembeau et al., 2007) and judgments about another person’s emotional states (Lotze et al., 2007). Although IFG is generally associated with affective empathy (Fan et al., 2011; Kogler et al., 2020), there is also literature that found IFG activity during emotion inference in cognitive empathy (Hooker et al., 2008).

Although the TPJ along with the STG are commonly associated with cognitive empathy, they were not significantly activated during cognitive empathy questions in our task. The TPJ is usually involved in the recognition of intentions and goals behind behaviors (Van Overwalle & Baetens, 2009). However, significant activations in the right TP could be primarily involved in the mentalizing processing of our task (Frith & Frith, 2003) rather than regions located more superior in the temporal lobe.

Finally, among the other areas involved in cognitive empathy, the fusiform gyrus has been reported to be associated with facial perception, particularly in response to unpleasant pictures compared to the baseline condition (Aldhafeeri et al., 2012).

In summary, cognitive empathy requires actively thinking and inferring about others’ actions, intentions, and emotional states in the specific interactive context, in which both ventral and dorsal PFC areas are involved. This processing demands effort, and high-level cognition, comprising mentalization in which the activation of the TP plays a fundamental role. Moreover, the involvement of the fusiform gyrus in face processing along with other areas such as the cuneus, SMA, or cerebellum demonstrates the complexity of this ability.

4.2.1. Cognitive empathy by adopting the victim’s perspective

Concerning the perspective factor, no differences have been found in our study comparing victim and offender performance during cognitive empathy. However, cognitive empathy questions in the victim, compared to the offender condition, significantly activated the right SMG and left precentral gyrus. Nummenmaa et al. (2008) also found significant activation in SMG while empathizing with victims compared to offenders. They concluded that this SMG activation is associated with the active mirroring of the emotional states of victims and might be involved in emotional contagion. The increased activity in SMG is usually associated with distinguishing between self and others' emotional states and overcoming emotional egocentricity during empathic judgments (Kanske et al., 2015; Silani et al., 2013). The SMG is considered a core area of cognitive empathy, particularly in inferring the emotional state of others in painful situations (Kogler et al., 2020). Other studies that target empathy found similar results when asking about the protagonist's emotions (Corradi-Dell'Acqua et al., 2014), or empathy for pain vs other emotions (Morelli et al., 2014). Additionally, the increased activity in the precentral gyrus aligns with previous findings of its involvement in emotion inference related to mentalizing and self-reported empathy (Hooker et al., 2008). Considering the findings from previous research, our results showing increased activity in these regions associated with self-other distinction, and attribution of emotions, provide support for the idea of heightened emotional contagion processing when focusing on victims compared to offenders in a violent context.

The activation of TP and SMG during empathy towards victims suggests their key role in making inferences about affective and cognitive actor's states when watching violent scenes. This finding can inform interventions aimed at enhancing perspective-taking abilities and promoting empathy in patients with empathy and mentalizing deficits, e.g., antisocial personality disorder. New techniques such as fMRI neurofeedback could target the right TP or SMG to make these patients learn how to up-regulate these regions (Sitaram et al., 2014).

4.3. Regression analysis

More negative emotional ratings during emotional videos were associated with greater activity in the right precuneus and the left postcentral gyrus. This indicates that these brain regions are significantly more active when someone has increased negative feelings during violent video exposure, irrespective of victim vs. offender focus. In a recent meta-analysis by Kogler et al. (2020), the precuneus has been described as a core region for empathy. In addition, it has been associated with self-referential processing (Schulte-Rüther et al., 2007), with a special emphasis on the evaluation of own emotional states during social interactions. Thus, our task though presenting violent and unpleasant images may elicit a very negative emotional state evaluation mediated by the precuneus activity. In addition, the postcentral gyrus has previously been linked to how a person receiving pain would feel, as well as to action comprehension (Timmers et al., 2018). In this vein, it is a consideration that our participants would show more negative emotions when inferring how the protagonists from our stimuli might feel when receiving pain. In contrast to the emotional ratings, there was no linear relationship between affective or cognitive empathy ratings and brain activity.

The present study has some limitations. First of all, in our main analyses, we used a straight statistical correction method (height threshold of $p < .05$ FWE) to address the problem of multiple comparisons and in order to control for type-I errors. However, the small sample size may cause reduced statistical power, which in turn might increase the propensity of type-II errors, not least in the context of our multifactorial study design. To address this problem, we also included uncorrected results at a voxel level of $p < .001$ with a corrected cluster level threshold of $p < .05$ FWE. Although the latter is common practice in fMRI research, future studies should be carried out with bigger samples to replicate the present findings with increased statistical power. Another limitation is that the sample only includes male young adults which limits the generalizability of the results at the population level. Also, it would have been convenient to include a measure of alexithymia defined as the difficulty in identifying and expressing one's own emotional states since there is a prevalence of approximately 10% in male young adults (Kokkonen et al., 2001) and it has been associated with empathy and ToM deficits (Demers & Koven, 2015). Moreover, alexithymia mediated the relationship between aggression and lack of empathy using the EmpaToM task (Winter et al., 2017). Another important point regarding the interpretation of our findings is related to the problem of inverse interference. Labeling conditions as "affective empathy" or “cognitive empathy” aligns with the task instructions and accurately reflects the explicit goal of assessing affective or cognitive aspects of empathy, based on participants' engagement with the emotional and perspective content. Accordingly, our results can reflect brain activation patterns affected by the underlying conditions. No vice versa conclusions are valid. Further studies need to be carried out to investigate the specificity of the neural patterns reported here. Furthermore, as in most studies of empathy and other cognitive processes, it remains challenging to determine definitively the cognitive processes occurring in participants’ minds, as well as the extent to which they follow the indicated instructions and genuinely engage in empathetic responses towards the actors. However, discernible variations in behavioral patterns may provide indicative evidence suggesting participants' compliance with the task requirements. Although the present results are largely in line with other studies, another point of criticism is the lack of established measures of empathy, which should also be taken into account in upcoming research. Finally, future studies may also methodically control study participants' attentional focus, e.g. by using eye-tracking techniques to ensure they are actually following instructions and also improve the interpretability of the data to see if there are differences at the attentional level when comparing the different perspectives.

5. Conclusion

The BACET is the first task to study affective and cognitive empathy while taking victim and offender perspectives into account. In summary, our results suggest that the BACET can differentiate both aspects of affective and cognitive empathy as well as the observer's perspective at behavioral and neural levels. Empathy towards victims significantly activated the right temporal pole, supramarginal gyrus, and left precentral cortex, while focusing on the offender’s role activated lingual gyrus. Our results thus may provide relevant methodological implications reflecting the importance of differentiating both components of empathy, as well as the possibility of taking into account different perspectives when empathizing with the different actors involved in social interaction. From a clinical point of view, this task may have potential especially for specific at-risk populations, such as people with an antisocial personality disorder or alexithymia, to further explore the relationship between empathy and aggression or violent offending. Particularly the consideration of the perspective factor, i.e., the assessment of empathy towards offenders vs. victims, might be a relevant aim of future research regarding groups of individuals characterized by aggressive violent behavior.

Acknowledgments and role of funding source

This work was supported and funded by grants from the German Research Foundation (DFG): SCHI 1034/7-1.

Conflict of interest statement

All authors stated no conflict of interest.

Author contribution

Lucia Hernandez-Pena: Investigation, Visualization, Formal analysis, writing – original draft, Kathrin Weidacker: Methodology, Software, writing – review and editing, Claudia Massau: Investigation, Anna-Lena Brand: Investigation, Katharina Weckes: Investigation, Wetzel, Kai: Investigation, Mareile Opwis: Methodology, writing - review and editing, Boris Schiffer: Funding acquisition, writing – review and editing, Christian Kärgel: Investigation, Supervision, Formal analysis, writing – review and editing.

References

Aldhafeeri, F. M., Mackenzie, I., Kay, T., Alghamdi, J., & Sluming, V. (2012). Regional brain responses to pleasant and unpleasant IAPS pictures: Different networks. *Neuroscience Letters, 512*(2), 94-98. https://doi.org/10.1016/j.neulet.2012.01.064.

Bradley, M. M., Sabatinelli, D., Lang, P. J., Fitzsimmons, J. R., King, W., & Desai, P. (2003). Activation of the visual cortex in motivated attention. *Behavioral Neuroscience, 117*(2), 369. https://doi.org/10.1037/0735-7044.117.2.369.

Burianova, H., McIntosh, A. R., & Grady, C. L. (2010). A common functional brain network for autobiographical, episodic, and semantic memory retrieval. *NeuroImage, 49*(1), 865-874. https://doi.org/10.1016/j.neuroimage.2009.08.066.

Bzdok, D., Langner, R., Schilbach, L., Jakobs, O., Roski, C., Caspers, S., Laird, A. R., Fox, P. T., Zilles, K., & Eickhoff, S. B. (2013). Characterization of the temporo-parietal junction by combining data-driven parcellation, complementary connectivity analyses, and functional decoding. *NeuroImage, 81,* 381-392. https://doi.org/10.1016/j.neuroimage.2013.05.046.

Bzdok, D., Schilbach, L., Vogeley, K., Schneider, K., Laird, A. R., Langner, R., & Eickhoff, S. B. (2012). Parsing the neural correlates of moral cognition: ALE meta-analysis on morality, theory of mind, and empathy. *Brain Structure and Function, 217*(4), 783-796. https://doi.org/10.1007/s00429-012-0380-y

Carr, L., Iacoboni, M., Dubeau, M. C., Mazziotta, J. C., & Lenzi, G. L. (2003). Neural mechanisms of empathy in humans: a relay from neural systems for imitation to limbic areas. *Proceedings of the national Academy of Sciences, 100*(9), 5497-5502. https://doi.org/10.1073/pnas.0935845100.

Corradi-Dell’Acqua, C., Hofstetter, C., & Vuilleumier, P. (2014). Cognitive and affective theory of mind share the same local patterns of activity in posterior temporal but not medial prefrontal cortex. *Social Cognitive and Affective Neuroscience, 9*(8), 1175-1184. https://doi.org/10.1093/scan/nst097.

D'Argembeau, A., Ruby, P., Collette, F., Degueldre, C., Balteau, E., Luxen, A., Maquet, P., & Salmon, E. (2007). Distinct regions of the medial prefrontal cortex are associated with self-referential processing and perspective taking. *Journal of Cognitive Neuroscience, 19*(6), 935-944. https://doi.org/10.1162/jocn.2007.19.6.935.

de Greck, M., Wang, G., Yang, X., Wang, X., Northoff, G., & Han, S. (2012). Neural substrates underlying intentional empathy. *Social Cognitive and Affective Neuroscience, 7*(2), 135-144. https://doi.org/10.1093/scan/nsq093.

De Vignemont, F., & Singer, T. (2006). The empathic brain: How, when and why? *Trends in Cognitive Sciences, 10*(10), 435-441. https://doi.org/10.1016/j.tics.2006.08.008.

Decety, J., & Jackson, P. L. (2004). The functional architecture of human empathy. *Behavioral and Cognitive Neuroscience Reviews, 3*(2), 71-100. https://doi.org/10.1177/1534582304267187.

Decety, J., & Lamm, C. (2006). Human empathy through the lens of social neuroscience. *The Scientific World Journal, 6*, 1146-1163. https://doi.org/10.1100/tsw.2006.221.

Decety, J., & Porges, E. C. (2011). Imagining being the agent of actions that carry different moral consequences: An fMRI study. *Neuropsychologia, 49*(11), 2994-3001. https://doi.org/10.1016/j.neuropsychologia.2011.06.024.

Demers, L. A., & Koven, N. S. (2015). The relation of alexithymic traits to affective theory of mind. *The American journal of psychology, 128*(1), 31-42. https://doi.org/10.5406/amerjpsyc.128.1.0031.

Deragotis, L. R. (1986). Symptom Checklist-90-R: Administration, Scoring, and Procedures Manual. National Computer Systems.

Dodell-Feder, D., Koster-Hale, J., Bedny, M., & Saxe, R. (2011). fMRI item analysis in a theory of mind task. *NeuroImage, 55*(2), 705-712. https://doi.org/10.1016/j.neuroimage.2010.12.040.

Eres, R., Decety, J., Louis, W. R., & Molenberghs, P. (2015). Individual differences in local gray matter density are associated with differences in affective and cognitive empathy. *NeuroImage, 117*, 305-310. https://doi.org/10.1016/j.neuroimage.2015.05.038.

Fan, Y., Duncan, N. W., de Greck, M., & Northoff, G. (2011). Is there a core neural network in empathy? an fMRI based quantitative meta-analysis. *Neuroscience & Biobehavioral Reviews, 35*(3), 903-911. https://doi.org/10.1016/j.neubiorev.2010.10.009.

Frith, C. D., & Frith, U. (2006). The neural basis of mentalizing. *Neuron, 50*(4), 531-534. https://doi.org/10.1016/j.neuron.2006.05.001.

Frith, C. D., & Frith, U. (2012). Mechanisms of social cognition. *Annual Review of Psychology, 63,* 287-313. https://doi.org/10.1146/annurev-psych-120710-100449.

Frith, C., & Frith, U. (2005). Theory of mind. *Current Biology, 15*(17), R644-R645. https://doi.org/10.1016/j.cub.2005.08.041.

Frith, U., & Frith, C. D. (2003). Development and neurophysiology of mentalizing. *Philosophical Transactions of the Royal Society of London.Series B: Biological Sciences, 358*(1431), 459-473. https://doi.org/10.1098/rstb.2002.1218.

Fusar-Poli, P., Placentino, A., Carletti, F., Allen, P., Landi, P., Abbamonte, M., Barale, F., Perez, J., McGuire, P., & Politi, P. L. (2009). Laterality effect on emotional faces processing: ALE meta-analysis of evidence. *Neuroscience Letters, 452*(3), 262-267. https://doi.org/10.1016/j.neulet.2009.01.065.

Gallagher, H. L., & Frith, C. D. (2004). Dissociable neural pathways for the perception and recognition of expressive and instrumental gestures. *Neuropsychologia, 42*(13), 1725-1736. https://doi.org/10.1016/j.neuropsychologia.2004.05.006.

Hooker, C. I., Verosky, S. C., Germine, L. T., Knight, R. T., & D’Esposito, M. (2008). Mentalizing about emotion and its relationship to empathy. *Social Cognitive and Affective Neuroscience, 3*(3), 204-217. https://doi.org/10.1093/scan/nsn019.

Kanske, P., Böckler, A., Trautwein, F., & Singer, T. (2015). Dissecting the social brain: Introducing the EmpaToM to reveal distinct neural networks and brain–behavior relations for empathy and theory of mind. *NeuroImage, 122*, 6-19. https://doi.org/10.1016/j.neuroimage.2015.07.082.

Klimecki, O. M., Leiberg, S., Ricard, M., & Singer, T. (2014). Differential pattern of functional brain plasticity after compassion and empathy training. *Social Cognitive and Affective Neuroscience, 9*(6), 873-879. https://doi.org/10.1093/scan/nst060.

Kogler, L., Müller, V. I., Werminghausen, E., Eickhoff, S. B., & Derntl, B. (2020). Do I feel or do I know? Neuroimaging meta-analyses on the multiple facets of empathy. *Cortex*, *129*, 341-355. https://doi.org/10.1093/scan/nst060.

Kokkonen, P., Karvonen, J. T., Veijola, J., Läksy, K., & Jokelainen, J. (2001). Perceived and sociodemographic correlates of alexithymia in a population sample of young adults. *Comprehensive Psychiatry*, *42*(6), 471-476. https://doi.org/10.1053/comp.2001.27892.

Lamm, C., Decety, J., & Singer, T. (2011). Meta-analytic evidence for common and distinct neural networks associated with directly experienced pain and empathy for pain. *NeuroImage, 54*(3), 2492-2502. https://doi.org/10.1016/j.neuroimage.2010.10.014.

Lawrence, E. J., Shaw, P., Giampietro, V. P., Surguladze, S., Brammer, M. J., & David, A. S. (2006). The role of 'shared representations' in social perception and empathy: An fMRI study. *NeuroImage, 29*(4), 1173-1184. https://doi.org/10.1016/j.neuroimage.2005.09.001.

Lehrl, S. Mehrfachwahl-Wortschatz-Intelligenztest (MWT-B) [Multiple Choice Vocabulary Intelligence Test] (2005). Spitta Verlag.

Legrain, V., Iannetti, G. D., Plaghki, L., & Mouraux, A. (2011). The pain matrix reloaded: a salience detection system for the body. Progress in Neurobiology, 93(1), 111-124.

Lockwood, P. L. (2016). The anatomy of empathy: Vicarious experience and disorders of social cognition. *Behavioural Brain Research, 311*, 255-266. https://doi.org/10.1016/j.bbr.2016.05.048.

Lockwood, P. L., Seara-Cardoso, A., & Viding, E. (2014). Emotion regulation moderates the association between empathy and prosocial behavior. *PloS One, 9*(5). https://doi.org/10.1371/journal.pone.0096555.

Lotze, M., Veit, R., Anders, S., & Birbaumer, N. (2007). Evidence for a different role of the ventral and dorsal medial prefrontal cortex for social reactive aggression: An interactive fMRI study. *Neuroimage, 34*(1), 470-478. https://doi.org/10.1016/j.neuroimage.2006.09.028.

Miller, F., & Wallis, J. (2011). Social interaction and the role of empathy in information and knowledge management: A literature review. *Journal of Education for Library and Information Science*, 122-132. http://www.jstor.org/stable/41308887.

Mitchell, J. P. (2005). The false dichotomy between simulation and theory-theory: The argument's error. *Trends in Cognitive Sciences, 9*(8), 363-364. https://doi.org/10.1016/j.tics.2005.06.010.

Molenberghs, P., Johnson, H., Henry, J. D., & Mattingley, J. B. (2016). Understanding the minds of others: A neuroimaging meta-analysis. *Neuroscience & Biobehavioral Reviews, 65*, 276-291. https://doi.org/10.1016/j.neubiorev.2016.03.020.

Molnar-Szakacs, I. (2011). From actions to empathy and morality–A neural perspective. *Journal of Economic Behavior & Organization, 77*(1), 76-85. https://doi.org/10.1016/j.jebo.2010.02.019.

Morawetz, C., Bode, S., Derntl, B., & Heekeren, H. R. (2017). The effect of strategies, goals and stimulus material on the neural mechanisms of emotion regulation: A meta-analysis of fMRI studies. *Neuroscience & Biobehavioral Reviews, 72*, 111-128. https://doi.org/10.1016/j.neubiorev.2016.11.014.

Morelli, S. A., Rameson, L. T., & Lieberman, M. D. (2014). The neural components of empathy: Predicting daily prosocial behavior. *Social Cognitive and Affective Neuroscience, 9*(1), 39-47. https://doi.org/10.1093/scan/nss088.

Nomi, J. S., Scherfeld, D., Friederichs, S., Schäfer, R., Franz, M., Wittsack, H., Azari, N. P., Missimer, J., & Seitz, R. J. (2008). On the neural networks of empathy: A principal component analysis of an fMRI study. *Behavioral and Brain Functions, 4*(1), 1-13. https://doi.org/10.1186/1744-9081-4-41.

Nummenmaa, L., Hirvonen, J., Parkkola, R., & Hietanen, J. K. (2008). Is emotional contagion special? an fMRI study on neural systems for affective and cognitive empathy. *NeuroImage, 43*(3), 571-580. https://doi.org/10.1016/j.neuroimage.2008.08.014.

Raposo, A., Vicens, L., Clithero, J. A., Dobbins, I. G., & Huettel, S. A. (2011). Contributions of frontopolar cortex to judgments about self, others and relations. *Social Cognitive and Affective Neuroscience, 6*(3), 260-269. https://doi.org/10.1093/scan/nsq033.

Rascle, O., Traclet, A., Souchon, N., Coulomb-Cabagno, G., & Petrucci, C. (2010). Aggressor-victim dissent in perceived legitimacy of aggression in soccer: The moderating role of situational background. *Research Quarterly for Exercise and Sport, 81*(3), 340-348. https://doi.org/10.1080/02701367.2010.10599682.

Schulte-Rüther, M., Markowitsch, H. J., Fink, G. R., & Piefke, M. (2007). Mirror neuron and theory of mind mechanisms involved in face-to-face interactions: a functional magnetic resonance imaging approach to empathy. *Journal of cognitive neuroscience*, *19*(8), 1354-1372. https://doi.org/10.1162/jocn.2007.19.8.1354.

Schurz, M., Radua, J., Aichhorn, M., Richlan, F., & Perner, J. (2014). Fractionating theory of mind: A meta-analysis of functional brain imaging studies. *Neuroscience & Biobehavioral Reviews, 42*, 9-34. https://doi.org/10.1016/j.neubiorev.2014.01.009.

Shamay-Tsoory, S. G. (2011). The neural bases for empathy. *The Neuroscientist, 17*(1), 18-24. https://doi.org/10.1177/1073858410379268.

Shamay-Tsoory, S. G., Aharon-Peretz, J., & Perry, D. (2009). Two systems for empathy: A double dissociation between emotional and cognitive empathy in inferior frontal gyrus versus ventromedial prefrontal lesions. *Brain, 132*(3), 617-627. https://doi.org/10.1093/brain/awn279.

Shamay-Tsoory, S. G., Shur, S., Barcai-Goodman, L., Medlovich, S., Harari, H., & Levkovitz, Y. (2007). Dissociation of cognitive from affective components of theory of mind in schizophrenia. *Psychiatry Research, 149*(1-3), 11-23. https://doi.org/10.1016/j.psychres.2005.10.018.

Silani, G., Lamm, C., Ruff, C. C., & Singer, T. (2013). Right supramarginal gyrus is crucial to overcome emotional egocentricity bias in social judgments. *Journal of Neuroscience, 33*(39), 15466-15476. https://doi.org/10.1523/JNEUROSCI.1488-13.2013.

Singer, T., & Lamm, C. (2009). The social neuroscience of empathy. *Annals of the New York Academy of Sciences, 1156*(1), 81-96. https://doi.org/10.1111/j.1749-6632.2009.04418.x.

Singer, T., Seymour, B., O'doherty, J., Kaube, H., Dolan, R. J., & Frith, C. D. (2004). Empathy for pain involves the affective but not sensory components of pain. *Science, 303*(5661), 1157-1162. https://doi.org/10.1126/science.1093535.

Sitaram, R., Caria, A., Veit, R., Gaber, T., Ruiz, S., & Birbaumer, N. (2014). Volitional control of the anterior insula in criminal psychopaths using real-time fMRI neurofeedback: a pilot study. *Frontiers in Behavioral Neuroscience, 8,* 344.

Strenziok, M., Krueger, F., Deshpande, G., Lenroot, R. K., van der Meer, E., & Grafman, J. (2011). Fronto-parietal regulation of media violence exposure in adolescents: A multi-method study. *Social Cognitive and Affective Neuroscience, 6*(5), 537-547. https://doi.org/10.1093/scan/nsq079.

Timmers, I., Park, A. L., Fischer, M. D., Kronman, C. A., Heathcote, L. C., Hernandez, J. M., & Simons, L. E. (2018). Is empathy for pain unique in its neural correlates? A meta-analysis of neuroimaging studies of empathy. *Frontiers in Behavioral Neuroscience, 12*, 289. https://doi.org/10.3389/fnbeh.2018.00289.

Van den Stock, J., Hortensius, R., Sinke, C., Goebel, R., & De Gelder, B. (2015). Personality traits predict brain activation and connectivity when witnessing a violent conflict. *Scientific Reports, 5*, 13779. https://doi.org/10.1038/srep13779.

Van Overwalle, F., & Baetens, K. (2009). Understanding others' actions and goals by mirror and mentalizing systems: A meta-analysis. *NeuroImage, 48*(3), 564-584. https://doi.org/10.1016/j.neuroimage.2009.06.009.

Völlm, B. A., Taylor, A. N., Richardson, P., Corcoran, R., Stirling, J., McKie, S., Deakin, J. F., & Elliott, R. (2006). Neuronal correlates of theory of mind and empathy: a functional magnetic resonance imaging study in a nonverbal task. *NeuroImage, 29*(1), 90-98. https://doi.org/10.1016/j.neuroimage.2005.07.022.

Walter, H. (2012). Social cognitive neuroscience of empathy: Concepts, circuits, and genes. *Emotion Review, 4*(1), 9-17. https://doi.org/10.1177/1754073911421379.

Whitehead, C., Marchant, J. L., Craik, D., & Frith, C. D. (2009). Neural correlates of observing pretend play in which one object is represented as another. *Social Cognitive and Affective Neuroscience, 4*(4), 369-378. https://doi.org/10.1093/scan/nsp021.

Winter, K., Spengler, S., Bermpohl, F., Singer, T., & Kanske, P. (2017). Social cognition in aggressive offenders: Impaired empathy, but intact theory of mind. *Scientific Reports, 7*(1), 1-10. https://doi.org/10.1038/s41598-017-00745-0.