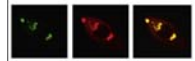


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## Research Report

# Neural correlates of the empathic perceptual processing of realistic social interaction scenarios displayed from a first-order perspective

T. Fehr<sup>a,b,c,d,\*</sup>, A. Achtziger<sup>h</sup>, G. Roth<sup>e</sup>, D. Strüber<sup>f,g</sup><sup>a</sup>Center for Cognitive Sciences, Department of Neuropsychology, University of Bremen, Hochschulring 18, 28359 Bremen, Germany<sup>b</sup>Center for Advanced Imaging, University of Bremen, Germany<sup>c</sup>Center for Advanced Imaging, University of Magdeburg, Germany<sup>d</sup>Department of Neurology II, Otto-von-Guericke-University, Magdeburg, Germany<sup>e</sup>Brain Research Institute, University of Bremen, Germany<sup>f</sup>Department of Experimental Psychology, Carl von Ossietzky University, Oldenburg, Germany<sup>g</sup>Research Center Neurosensory Science, Carl von Ossietzky University, Oldenburg, Germany<sup>h</sup>Chair of Social and Economic Psychology, Zeppelin University, Friedrichshafen, Germany

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## ABSTRACT

The neural processing of impulsive behavior is a central topic in various clinical and non-clinical contexts. To investigate neural and behavioral correlates of the empathic processing of complex social scenarios, especially considering ecological validity of the experimental procedure, we developed and investigated a video stimulus inventory. It includes realistic neutral, social-positive, and reactive-aggressive action scenarios. Short video-clips showing these social scenarios from a first-person perspective triggering different emotional states were presented to a non-clinical sample of 20 young adult male participants during fMRI measurements. Both affective interaction conditions (social-positive and reactive-aggressive) were contrasted against a neutral baseline condition and against each other. Behavioral evaluation data largely confirmed the validity of the emotion-inducing stimulus material. Reactive-aggressive and social-positive interaction scenarios produced widely overlapping fMRI activation patterns in hetero-modal association cortices, but also in subcortical regions, such as the peri-aqueductal gray. Reactive-aggressive compared to social-positive scenarios yielded a more anterior distribution of activations in pre-motor and inferior frontal brain regions associated to motor-preparation and inhibitory control processing as well as in the insula associated to pain-and/or aversion-processing. We argue that there are both principally common neural networks recruited for the processing of reactive-aggressive and social-positive scenarios, but also exclusive network parts in particular involved depending on individual socialization.

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\*Corresponding author at: Center for Cognitive Sciences, Department of Neuropsychology, University of Bremen, Hochschulring 18, 28359 Bremen, Germany. Fax: +49 421 218 68759.

E-mail address: [fehr@uni-bremen.de](mailto:fehr@uni-bremen.de) (T. Fehr).

## 1. Introduction

### 1.1. Aggressive behavior seems to be a common phenomenon in humans – also in healthy and law-abiding individuals

Aggression serves important purposes in self-defence and in securing mates, territory, and food (Gendreau and Archer, 2005). While these basic adaptive functions of aggression might be mediated by evolutionarily conserved bottom-up mechanisms, humans also developed culture and social norms, which set the boundaries of appropriate aggressive behavior that has to be achieved by regulatory top-down processes learned during lifelong socialization. There is a growing body of evidence that self-control, i.e., the capacity to override and restrain socially inappropriate behavior, serves to control aggressive impulses (e.g., Achtziger and Bayer, 2013; Baumeister et al., 1994; Bayer et al., 2009; Robertson et al., 2012; and see Strüber et al., 2008; Wahl, 2009, for reviews).

The proximal cause for many acts of real-world aggression has been discussed as a temporary loss of self-control (Baumeister et al., 1994; DeWall et al., 2007), which is characteristic of a reactive-impulsive type of aggression. This aggression is triggered by a perceived threat or provocation and involves exaggerated levels of negative emotion, such as fear or anger (Ramirez and Andreu, 2006). Barratt et al. (1999) observed a relatively high prevalence of impulsive aggression even in a sample of non-clinical participants (college students) suggesting that impulsive aggression may be more common in the general population than has been estimated. According to the authors, many of the aggressive acts reported by college students represented even extreme aggressive acts (e.g., attacking the boyfriend with a knife). Given that aggressive behavior is common among physically and mentally healthy and law-abiding people, the question arises for its neural underpinnings. The present study tries to follow an ecologically valid way to examine this basic question.

### 1.2. Different approaches in research on neural correlates of human aggression and their ecological validity

One critical aspect in research on neural correlates of aggression is the remarkable variety in brain activation patterns found across studies (see e.g., Strüber et al. 2008; Fehr, 2012), which might be related to the different experimental approaches to induce anger and aggression or other emotional brain responses (see Phan et al., 2002; Lange et al., 2003). Current neuroimaging studies on this topic used a variety of emotional induction methods including video-clips (e.g., Hasson et al., 2004; Fehr et al., 2007a), static facial expressions (e.g., Blair et al., 1999; Grosbras and Paus, 2006; Jackson et al., 2008; Kesler/West et al., 2001), interactive video games or computer game related virtual and real video stimulation (King et al., 2006; Mathiak and Weber, 2006; Regenbogen et al., 2010), imagery/recall of angry or violent situations (Damasio et al., 2000; Kimbrell et al., 1999; Dougherty et al., 1999; Pietrini et al., 2000), and classic laboratory tasks like the Taylor Aggression Paradigm (Lotze

et al., 2007; Krämer et al., 2007). Neural correlates of the processing of aggression-related stimulation were distributed in multiple brain regions including widespread cortical, sub-cortical and limbic, and even cerebellar brain areas.

Another critical aspect in research on the neural correlates of anger and reactive-impulsive aggression is the ecological validity of the experimental designs. As mentioned above, interpersonal provocation is an important aspect in real-world aggression and was described as “perhaps the most important single cause of human aggression” (Anderson and Bushman, 2002, p. 37). Game-like experimental approaches such as for instance the Taylor Aggression Paradigm (TAP; Taylor, 1967) were successfully applied in functional neuroimaging studies (Lotze et al., 2007; Krämer et al., 2007), induced reliably reactive aggression in the laboratory context and showed good construct validity (Giancola and Zeichner, 1995). However, their relevance for the investigation of real-world aggression might be limited given the abstract, unrealistic, and inflexible nature of the applied virtual tasks (see Tedeschi and Quigley, 1996). It is further unclear, whether laboratory experiments so far covered real-live-related processing of aggression and violence in the brain, or whether they just represented a kind of *minor* aggression (see Ferguson and Dyck, 2012). Therefore, previous laboratory-approaches might have underestimated the phenomenon of interest (i.e., real-like aggression- and violence-processing in the human brain) or even completely failed to capture it in an appropriate way (see also Yang and Mulvey, 2012). The here presented experimental procedure was developed to receive stimuli with high ecological validity by ensuring that they were strongly characterized by real-live-related properties of aggressive social interactions.

### 1.3. An new experimental approach to activate aggression-related brain structures

Numerous studies showed that the presentation or the recall of action-related cues such as for instance action-related words and actions presented in video-clips produce activation patterns in brain regions that are thought to be directly or indirectly associated with real motor execution (e.g., Aziz-Zadeh et al., 2006; Buccino et al., 2001; Chaminade et al., 2002; Choi et al., 2001; Decety et al., 1997; Formaggio et al., 2010; Grézes et al., 1999; Jirak et al., 2010; Lyons et al., 2010; Molnar-Szakacs et al., 2005; Ueno et al., 2010). This phenomenon has been discussed in relation to real motor behavior preparation (e.g., Chaminade et al., 2002). Therefore, the presentation of realistic action-related information should trigger the recruitment of neural resources, which are related to real motor actions or at least to their planning.

Stimuli with dynamic content prominently produced higher arousal rates (Simons et al., 1999; Weyers et al., 2006) and better recognition accuracy (Ambadar et al., 2005; Bassili, 1979; Harwood et al., 1999) when participants were asked to rate dynamic compared to static emotional facial expressions. Furthermore, the recruitment of neural resources for the emotional appraisal of the respective stimuli was shown to be extended for dynamic stimuli (e.g., Trautmann et al., 2009; Trautmann-Lengsfeld et al., 2013), which was discussed in terms of higher ecological validity of dynamic and therefore more naturalistic stimulation procedures. In accordance to

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