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Increased neural reactivity to socio-emotional stimuli links social exclusion and aggression

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ABSTRACT

We investigated changes in the neural processing of social information as possible link between social exclusion and aggression. Participants played a virtual ball game with two putative game partners, during which half of the 34 participants were excluded. Then, participants played the Taylor Aggression Paradigm (TAP) against the same partners. An empathy paradigm followed, in which participants watched pictures of neutral and emotional social scenes, while undergoing functional magnetic resonance imaging (fMRI). Excluded participants showed stronger neural reactivity to emotional compared to neutral pictures than included participants in regions associated with cognitive mentalizing and the mirror neuron system (bilateral superior, middle and inferior temporal gyrus, bilateral precuneus, right precentral gyrus). Reactivity of left inferior temporal gyrus and right precentral gyrus was positively correlated with aggressive behavior in the TAP. Our results support previous behavioral findings which suggest changes in social information processing as mediator between exclusion and aggression.

1. Introduction

1.1. Social exclusion and aggressive behavior

Forming and maintaining social bonds is considered a basic human need (Baumeister & Leary, 1995). Given the antisocial nature of aggressive behavior, it is somewhat counterintuitive that social exclusion, or interpersonal rejection, has been shown to elicit aggressive behavior in a variety of experimental settings (review in Leary, Twenge, & Quinlivan, 2006). Yet, ample evidence from longitudinal studies in children, for instance, indicates a vicious cycle of poor social skills or deficits in social information processing leading to peer rejection, which in turn increases antisocial behavior and negatively affects social information processing skills, making future peer rejection more likely (Lansford, Malone, Dodge, Pettit, & Bates, 2010; Miller-Johnson, Coie, Maumary-Gremaud, & Bierman, 2002). Evidencing such long-lasting effects, social exclusion during childhood was found to be associated with aggressive behavior in early adulthood (Rabiner, Coie, Miller-Johnson, Boykin, & Lochman, 2005).

Besides the long-term impact of social exclusion on aggression, numerous studies demonstrated short-term effects on antagonistic behavior. In an experimental setting involving both children and adults, Moor et al. (2012) found that in a dictator game (Cason & Mui, 1998) following exclusion in an online ball-tossing game, participants made more unfair offers toward those who excluded them than toward new partners. In a similar vein, Twenge, Baumeister, Tice, and Stucke (2001) found increased aggressive behavior in the Taylor Aggression Paradigm (TAP; Taylor, 1967) after participants were rejected by their peers. In contrast to the findings of Moor et al. (2012), aggression in this study was increased even toward new game partners, who had not been involved in the previous rejection.

1.2. Effects of social exclusion on social information processing

Different mechanisms have been suggested to mediate the relationship between social exclusion and aggression. According to the General Aggression Model of Anderson and Bushman (2002), frustration and subsequent negative affect, specifically anger, are common precursors of reactive aggressive behavior. However, in a meta-analysis of experimental and longitudinal studies on the consequences of rejection, Blackhart, Nelson, Knowles, and Baumeister (2009) come to the conclusion that “the immediate reaction to being rejected is a neutral emotional state rather than a negative one, on average.”

In a series of experiments by DeWall, Twenge, Gitter, and Baumeister (2009), participants who were told that they would likely be lonely in the future showed a cognitive bias toward aggressive words, which was associated with aggressive behavior toward their opponent in a reaction-time task. The authors conclude

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that increased aggression is a consequence of hostile cognition, rather than negative affect, leading the participant to perceive neutral information as antagonistic (DeWall, Twenge, et al., 2009). Increased attention to smiling faces and decreased attention to sad faces (DeWall, Maner, & Rouby, 2009), as well as reduced availability of emotional words (Twenge, Catanese, & Baumeister, 2003) after experienced or anticipated exclusion similarly suggest an effect of exclusion on the processing of socio-emotional stimuli.

Regarding the effect of exclusion on social information processing and its neural correlates, fMRI studies have highlighted changes in regions of the mentalizing network in particular. The mentalizing network comprises mPFC, TPJ, superior temporal sulcus (STS), temporal poles, inferior frontal gyrus (IFG) and precuneus and has reliably been found activated during the processing of socio-emotional stimuli (Carrington & Bailey, 2009; Singer, 2008). A subdivision into two partially overlapping neural networks reflecting cognitive theory-of-mind (ToM) processes (understanding the state of mind of another person) on the one hand and affective empathy (feeling the other person's emotions) on the other hand has been suggested. In his review, Lieberman (2007) concludes that cognitive ToM processes depend on a network including the dorsomedial PFC, STS, ventrolateral PFC and the lateral temporal cortex, whereas affective empathy is associated with a network including the anterior insula, the dorsal anterior cingulate cortex (dACC), ventromedial PFC (vmPFC) and medial PFC (mPFC), and also the dorsomedial PFC.

Cacioppo, Norris, Decety, Monteleone, and Nusbaum (2009) found that subjects scoring high on the UCLA Loneliness Scale (Russell, 1996) showed increased reactivity of occipital areas to negative social pictures, while non-lonely participants showed increased reactivity of the temporo-parietal junction (TPJ). The authors conclude that non-lonely participants are more likely to adopt the perspective of another person when seeing them in distress.

An effect of social exclusion on the processing of social stimuli was also observed by Powers, Wagner, Norris, and Heatherton (2011). In their study, participants were either told that they were likely to end up alone later in life, or to have many meaningful relations in their future (future alone paradigm; Twenge et al., 2001). Participants who had received the loneliness manipulation showed reduced activity in the medial PFC in response to negative social stimuli. The authors interpreted this as a protective mechanism, reflecting an avoidance of empathizing with or taking the perspective of people who pose a potential social threat.

These findings are in line with an experiment showing that excluded participants report less empathy with another person in distress (DeWall & Baumeister, 2006).

1.3. Current study

Combining the evidence from cognitive studies showing changes in social information processing after exclusion (DeWall, Maner, et al., 2009; DeWall, Twenge, et al., 2009; Lansford et al., 2010) and the above-mentioned neuroimaging results (Cacioppo et al., 2009; Powers et al., 2011), reactivity of the mentalizing network in response to socio-emotional stimuli seems a likely mediator of social exclusion effects on aggression. However, so far the effects of social exclusion on aggressive behavior and on neural reactivity to socio-emotional stimuli have not been investigated in a combined experimental design. In the following study, we combine the cyberball game described above, the Taylor Aggression Paradigm, and an fMRI-paradigm previously shown to reliably evoke activity in the mentalizing network (Krämer, Mohammadi, Donamayor, Samii, & Münte, 2010), such that changes in neural reactivity following exclusion can be related to aggressive behavior toward the perpetrators of the exclusion.

One well-established method for social exclusion in the laboratory is the cyberball game developed by Williams, Cheung, and Choi (2000), which has been adapted for the use with functional magnetic resonance imaging by Eisenberger, Lieberman, and Williams (2003). During cyberball, participants toss a ball back and forth in a virtual ball game with two ostensible partners. In the exclusion condition, the partners stop tossing the ball to the participant after a certain number of throws, thus excluding the participant from the game. In a recent fMRI-study using cyberball, Chester et al. (2013) found a positive correlation between the exclusion effect in the dACC and subsequent aggression in participants low in executive functioning, but the reverse effect in participants high in executive functions. However, this study did not address changes in social information processing after exclusion as possible mediator of the rejection–aggression relation.

The Taylor Aggression Paradigm (TAP) is a frequently used method for eliciting and measuring aggressive behavior in an experimental setting (Taylor, 1967). During the TAP, participants are led to believe that they are playing a competitive reaction time task against one or more opponents. Actually, both the opponent's behavior and the outcome of the reaction time task are under control of the experimenter. During each trial of the TAP, the winner of the task gets to punish the loser with an aversive stimulus of variable intensity. The intensity ostensibly chosen by the opponent serves as a manipulation of provocation, whereas the intensity selected by the participant serves as a measure of aggressive behavior. In its classical setting, the TAP simulates an opponent who selects increasing punishments during the course of the game, thus gradually increasing the level of provocation. Due to this provocative element, the TAP is considered a measure of reactive aggression. In their behavioral study investigating the effects of exclusion on aggression, Twenge et al. (2001) used as aggression measure only the first trial of the TAP. At this point, participants had not received any punishment from their opponent. Thus, this measure reflects the provocative effect of the exclusion experience independent of provocation during the TAP. In the current study, we were also interested in the effect of the exclusion alone and modified the TAP, such that the participant received only low to medium levels of punishment. In this form, the participants' aggressive behavior in the TAP is unprovoked.

On a behavioral level, we expected that participants who were excluded during the cyberball game would select higher punishment levels during the TAP, thus acting more aggressively toward their putative game partners. On a neural level, we expected that regions of the mentalizing network would show differential reactivity to socio-emotional stimuli for included vs. excluded participants, mediating the effect of social exclusion on aggressive behavior.

2. Methods

2.1. Participants

40 healthy volunteers (17 male) participated in this study. Participants were free of neurological and psychiatric disorders and all but two were right-handed (self-report). Mean age of the participants was 22.5 years (range 19–28). All participants gave written informed consent and received 7 Euro per hour as compensation for their participation. The study was approved by the local ethics committee and performed according to the Declaration of Helsinki.

2.2. Procedure

Upon arrival in the laboratory, participants were introduced to two game partners for the experiment, one male and one female,