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Neural correlates of retaliatory and prosocial reactions to social exclusion: Associations with chronic peer rejection

Geert-Jan Will[a,b,*], Eveline A. Crone[a,b], Pol A.C. van Lier[c], Berna Güroğlu[a,b]

[a] Institute of Psychology, Leiden University, The Netherlands
[b] Leiden Institute for Brain and Cognition (LIBC), Leiden University, The Netherlands
[c] Department of Developmental Psychology, Vrije Universiteit, Amsterdam, The Netherlands

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ABSTRACT

Social exclusion is a distressing experience and can lead to both retaliatory and prosocial reactions toward the sources of exclusion. The way people react to social exclusion has been hypothesized to be shaped through chronic exposure to peer rejection. This functional Magnetic Resonance Imaging study examined associations between chronic peer rejection and retaliatory (i.e. punishing) and prosocial (i.e. forgiving) reactions to social exclusion and the neural processes underlying them. Chronically rejected ($n = 19$) and stably highly accepted adolescents ($n = 27$) distributed money between themselves and unknown others who previously included or excluded them in a virtual ball-tossing game (Cyberball). Decreasing the excluders' monetary profits (i.e., punishment) was associated with increased activity in the ventral striatum, dorsolateral prefrontal cortex (PFC) and parietal cortex in both groups. Compared to stably highly accepted adolescents, chronically rejected adolescents exhibited higher activity in the dorsal striatum and lateral prefrontal cortex – brain regions implicated in cognitive control – when they refrained from punishment and shared their money equally with (i.e. forgave) the excluders. These results provide insights into processes that might underlie the maintenance of peer rejection across development, such as difficulties controlling the urge to retaliate after exclusion.

1. Introduction

From infancy to old age, humans have a fundamental need to form and maintain lasting positive relationships with others (Baumeister and Leary, 1995). Social exclusion frustrates this need and can lead to retaliation toward the sources of exclusion (Twenge et al., 2007), but may also lead to prosocial responses aimed at reconnection; both toward potential new sources of affiliation (Maner et al., 2007) as well as the peers responsible for exclusion (Will et al., 2015). The way people react to social exclusion has been hypothesized to be shaped through exposure to prolonged rejection by close others, such as parents (Feldman and Downey, 1994), or peers (London et al., 2007). Indeed, children and adolescents with a history of chronic peer rejection become increasingly more likely to defensively expect, readily perceive, and overreact to social rejection (London et al., 2007) and show a heightened neural reactivity to social exclusion (Will et al., 2016). Yet, how the neural responses underlying *behavioral reactions* to exclusion vary as a function of a history of chronic peer rejection remains to be investigated. Therefore, we examined neural processes involved in retaliatory (i.e. punishing) and prosocial (i.e. forgiving) reactions to social exclusion in adolescents with a history of chronic peer rejection and tested how they differed from adolescents with a history of stable high levels of peer acceptance.

Peer rejection reflects the collective valence of negative sentiments in a group toward a specific individual in that group, which is most commonly assessed through asking group members who they like most (positive) and who they like least (negative) (Bukowski et al., 2000; Coie et al., 1982; Newcomb and Bukowski, 1983). Children who receive many negative nominations and very few positive nominations are classified as rejected and develop widespread impairments in daily life, ranging from conduct problems (Sturaro et al., 2011) to delinquency (Kupersmidt et al., 1995) and dropping out of school (Hymel et al., 1996). Transactional developmental models posit that such impairments arise out of a sustained pattern of reciprocal interactions between peers expressing dislike toward a rejected group member and the rejected member's reactions to being disliked (Coie, 1990; Sandstrom and Coie, 1999). Social exclusion – defined as excluding someone from a group or

* Corresponding author at: Institute of Psychology, Leiden University, Wassenaarseweg 52, 2333 AK, Leiden, The Netherlands.
E-mail address: g.j.will@fsw.leidenuniv.nl (G.-J. Will).

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activity – is one of the most common methods adolescents use to express dislike toward rejected peers (Coie, 1990). Transactional models predict that adolescents who react to exclusion with retaliatory vengeance might be more likely to elicit further rejection than those who show behavior aimed at reconnecting after exclusion. Preliminary support for this hypothesis comes from studies showing that adolescents with a rejected status report using more aggressive coping styles in response to social exclusion in a hypothetical scenario (Sandstrom, 2004). Elucidating the neurocognitive mechanisms underlying behavioral reactions to exclusion can further our understanding why some adolescents become trapped in a vicious cycle of chronic rejection and exclusion.

Neuroimaging studies have demonstrated that a history of peer rejection and accompanying intra- and interpersonal vulnerability factors are associated with enhanced neural responses to social exclusion in adolescence. Activity in the dorsal Anterior Cingulate Cortex (ACC) – a region involved in detecting and generating exclusion-related distress – during exclusion is enhanced in adolescents who were chronically rejected by peers during childhood (Will et al., 2016), who spent less time with friends (Masten et al., 2012), and those who anxiously and angrily expect exclusion (Masten et al., 2009). Extending our scope to the neural processes underlying *behavioral* reactions to social exclusion, and how they vary as a function of exposure to peer rejection, can increase our understanding of the processes underlying adolescents' decisions to seek revenge or reconnection after exclusion.

Neural processes underlying retaliatory and prosocial reactions to social exclusion have proven to be reliably examined by giving people the opportunity to distribute money between themselves and those who previously either included or excluded them (i.e. the includers and excluders respectively). People selectively punish the excluders by decreasing their monetary outcomes while treating the includers fairly. This form of punishment has been associated with increased activity in the pre-supplementary motor area (pre-SMA)/ACC and anterior insula (AI) (Gunther Moor et al., 2012; Will et al., 2015). Refraining from punishment and acting prosocial toward the excluders (i.e. forgiveness) through sharing a sum of money equally with them has been associated with increased activation in neural circuitry supporting social cognition (i.e., the temporo-parietal junction [TPJ] and the dorsomedial prefrontal cortex [dmPFC]) and executive control (i.e., lateral prefrontal cortex [lPFC]) (Gunther Moor et al., 2012; Will et al., 2015).

Well-established behavioral and cognitive signatures of a rejected (vs. an accepted) status inform our hypotheses about how neural processes underlying behavioral reactions to exclusion vary as a function of peer status history. In comparison with their accepted classmates, children with a rejected status are more likely to deal with interpersonal anger in aggressive ways that instigate further conflict (Fabes and Eisenberg, 1992; Rabiner et al., 1990). Furthermore, they exhibit deficits in social cognition (e.g. less sophisticated perspective-taking skills) and executive control (e.g. problems in impulse control and emotion regulation) skills (Dodge et al., 2003b; Eisenberg et al., 1997; Fink et al., 2014), which have been shown to be crucially involved in refraining from punishment and forgiving excluders. To be specific, lower levels of behavioral control are associated with higher levels of aggression toward excluders (Chester et al., 2013) and higher levels of perspective taking are associated with higher levels of forgiveness in the form of refraining from punishment and sharing a sum of money with excluders (Will et al., 2015). Based on these findings, we hypothesized that chronically rejected adolescents would show: 1) higher levels of punishment (and thus lower levels of forgiveness) toward excluders; 2) lower levels of perspective-taking and higher levels of executive control problems and 3) differential recruitment of neural circuitry supporting social cognition (e.g. dmPFC and TPJ) and executive control (e.g. lPFC) during forgiveness.

To test these hypotheses, we recruited participants whose acceptance and rejection among peers was assessed annually across six elementary school grades as part of a large-scale longitudinal study (Sturaro et al., 2011; van Lier and Koot, 2010). Using strict selection criteria, we invited a group of adolescents who were chronically rejected by peers and a group of adolescents who had a stable accepted status among peers to participate in the current study. While undergoing functional Magnetic Resonance Imaging (fMRI), they were first included and then excluded by two unknown adolescents in a virtual ball-tossing game called Cyberball (Williams et al., 2000). Subsequently, they played an economic game, previously validated in adults, in which they could either punish or forgive the excluders (Will et al., 2015). Results on the neural correlates of exclusion in Cyberball are reported elsewhere (see Ref. Will et al., 2016).

We anticipated that punishment of excluders would be associated with increased activity in the pre-SMA/ACC and AI (Sanfey et al., 2003; Strobel et al., 2011). In contrast, forgiveness was expected to be associated with increased activity in the dmPFC, TPJ and lPFC (Brüne et al., 2013; Will et al., 2015). With respect to individual differences, we expected that adolescents with a history of chronic peer rejection, relative to adolescents with a history of stable peer acceptance, would show enhanced recruitment of brain regions implicated in social cognition (e.g. dmPFC, TPJ) and executive control (e.g. lPFC) during forgiveness of excluders, consistent with findings demonstrating that adults who showed less forgiveness behavior activated these networks to a greater extent when they did decide to forgive (Will et al., 2015). To further explore how individual differences in social cognition (i.e. perspective taking) and executive control (i.e. behavioral regulation) were associated with punishment and forgiveness behavior and neural activity during forgiveness, we tested for correlations with self-reported perspective-taking and parent-reported behavioral regulation skills.

2. Material and methods

2.1. Participants and recruitment procedure

Participants were recruited from a longitudinal study ($N = 1189$) investigating the impact of social experiences on behavioral, emotional and academic outcomes between the ages of 6 and 12 (annually from first to sixth grade of elementary school). Each year, participants were asked to nominate the peers in their class whom they liked most and liked least (unlimited nominations). Using those nominations, an average social preference score (liked most – liked least nominations) across the six waves was calculated. Participants were identified as chronically rejected if they were in the lower 10th percentile of that 6-year average social preference and as stably highly accepted if they were in the upper 10th percentile. Using a 10% threshold insured that none of the chronically rejected adolescents were ever classified as sociometrically popular and none of the stably highly accepted adolescents were ever classified as rejected in any of the six waves. Correlations between social preference scores of adjacent years (rs 0.67–0.70, all $ps < 0.001$) were comparable to those reported in prior work (Salmivalli and Isaacs, 2005; Vitaro et al., 2007).

Based on these criteria, suitability for participation in an fMRI study and availability of recent contact information, 131 adolescents were asked to participate in the fMRI study. Twenty adolescents were excluded because they were either left-handed ($n = 4$), had an autism spectrum disorder ($n = 1$) or had braces ($n = 15$). Seven adolescents could not be reached. Of the remaining 104 candidate participants, 47 adolescents and their parents agreed to participate in the current fMRI study. Adolescents who