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Research report

Neural responses to social exclusion in adolescents: Effects of peer status

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ABSTRACT

We examined whether adolescents' neural responses to social exclusion and inclusion are influenced by their own popularity and acceptance and by the popularity of their excluders and includers. Accepted adolescents are highly prosocial. In contrast, popular adolescents, who are central and influential, show prosocial as well as antisocial behaviors, such as peer exclusion. Fifty-two 12–16 year-old adolescents underwent an functional magnetic resonance imaging (fMRI) scan while playing the ball-tossing game Cyberball in which they received or did not receive the ball from other virtual players. The other virtual players were described as either highly popular or average in popularity. Participants' own popularity and acceptance were assessed with peer nominations at school ($n = 31$). Participants' acceptance was positively correlated with activity of the dorsal anterior cingulate cortex (ACC) during exclusion. Participants' popularity was positively associated with ventral striatum and medial prefrontal cortex activity during exclusion, but only when the excluders were popular virtual players. Participants showed increased rostral ACC activation to inclusion by players who were average in popularity. These findings indicate that peer status plays an important role in adolescents' neural processing of social exclusion and inclusion. Moreover, these findings underscore that popularity and acceptance are distinct types of high peer status in adolescence, with not only distinct behavioral correlates, but also distinct neural correlates.

1. Introduction

Adolescents spend a lot of time interacting with peers (Steinberg & Morris, 2001). Not all of these interactions are positive; 41% of adolescents reported exclusion by their peers in the past two months (Wang, Iannotti, & Nansel, 2009). Frequent exclusion by peers can lead to maladaptive outcomes, including poor academic achievement (DeRosier, Kupersmidt, & Patterson, 1994), depression and anxiety (Ladd & Troop-Gordon, 2003), and aggression (Sturaro, van Lier, Cuijpers, & Koot, 2011).

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1.1. Peer status and social exclusion

Peer status plays a large role in social exclusion in adolescents' daily lives. In adolescence, two moderately correlated types of high status in the peer group are distinguished: acceptance and popularity (Cillessen & Rose, 2005; Parkhurst & Hopmeyer, 1998). Sociometric measures are frequently used to assess peer status in adolescents (Cillessen, 2009). Acceptance is measured by asking adolescents which classmates they like most and least, while popularity is measured by asking which classmates they perceive as most and least popular. Accepted adolescents show high levels of prosocial behaviors and low levels of antisocial behaviors (Sandstrom & Cillessen, 2006). In contrast, popular adolescents, who are central and influential in the peer group, show high levels of both prosocial and antisocial behaviors, such as peer exclusion (Cillessen & Mayeux, 2004; Rose, Swenson, & Waller, 2004).

Examining how peer status is associated with adolescents' responses to social exclusion is highly relevant, given that being popular in the peer group is a priority for many adolescents (LaFontana & Cillessen, 2010). Additionally, socially excluding peers allows adolescents to achieve and maintain popularity (Cillessen & Mayeux, 2004; Rose et al., 2004). While sociometric peer status measures have been widely used to study behavioral correlates of peer status (Cillessen, 2009), few studies have combined sociometric peer status measures with experimental paradigms of social exclusion. This interdisciplinary approach has several advantages. First, combining highly controlled experimental paradigms with well-established sociometric measures of peer status provides both excellent experimental control and high ecological validity, since sociometric peer status measures involve asking adolescents' real life peers (their classmates) about their status in this important peer group. Moreover, experimental paradigms of social exclusion can be combined with neuroimaging methods and sociometric measures of peer status, to investigate whether individual differences in neural responses to exclusion are a function of both the participants' own peer status and the peer status of the excluders.

1.2. Neural responses to social exclusion

The Cyberball paradigm is the most frequently used paradigm to study behavioral and neural responses to social exclusion in adolescents (Bolling et al., 2011; Gunther Moor et al., 2012; Masten et al., 2009; Sebastian et al., 2011; Will, van Lier, Crone, & Güroğlu, 2015). Cyberball is an online ball-tossing game that participants play with virtual players, whose behavior is preprogrammed (Williams & Jarvis, 2006). Participants are first included, and after a while, the virtual players stop throwing them the ball. Exclusion leads to reduced mood and decreased satisfaction of needs, accompanied by activation of the subgenual anterior cingulate cortex (sgACC; located underneath the genus of the corpus callosum; Vogt, 2005), ventral ACC (vACC; located more anterior than the sgACC, extending into the medial prefrontal cortex; Somerville, Kelley, & Heatherton, 2010), dorsal ACC (dACC), medial orbitofrontal cortex (mOFC), anterior insula and ventrolateral prefrontal cortex (VLPFC) (Bolling et al., 2011; Gunther Moor et al., 2012; Masten et al., 2009; Sebastian et al., 2011; Will, van Lier et al., 2015).

While the neural responses to social exclusion are relatively well-established, little is known about how these neural responses are associated with adolescents' peer status as indexed by sociometric measures (i.e., peer-report). Nevertheless, a handful of studies have explored how neural responses to exclusion are associated with self-reported or parent-reported social functioning or peer status. These prior studies have yielded mixed findings. Some researchers have reported *increased* activation of both emotion-processing regions (dACC, sgACC, insula) and emotion-regulation regions (dACC, VLPFC) in adolescents with more developed interpersonal skills (Masten et al., 2009). In contrast, other researchers observed *reduced* activation of emotion-processing regions (dACC, insula, medial prefrontal cortex; mPFC) in response to exclusion, in adolescents who spent more time with friends (Masten, Telzer, Fuligni, Lieberman, & Eisenberger, 2012), in adolescents who reported to be better able to resist peer influence (Sebastian et al., 2011), and in adolescent girls who reported to be stably accepted compared to adolescent girls who reported to be chronically rejected (Rudolph, Miernicki, Troop-Gordon, Davis, & Telzer, 2016).

1.3. Adolescents' peer status and neural responses to social exclusion

Will, van Lier et al. (2015) were the first to use sociometric measures to examine the association between peer status (i.e., acceptance) and neural responses to social exclusion in adolescents. They used an event-related Cyberball design, which allowed them to not only distinguish between exclusion and inclusion events, but also to focus on a third event: incidental exclusion. This refers to not receiving the ball in an inclusion block, in which participants are overall included but sometimes do not receive the ball, when the other players throw the ball to each other. Will, van Lier et al. (2015) argued that incidental exclusion might serve as a cue for potential rejection. They found that chronically rejected adolescents showed increased dACC activity during both exclusion and incidental exclusion, compared to stably accepted adolescents.

While the findings of Will, van Lier et al. (2015) provide intriguing insights into the association between acceptance and neural responses to exclusion, the association between these neural responses and popularity has remained unexplored, even though popularity is most strongly linked to involvement in social exclusion (Cillessen & Mayeux, 2004). Therefore, the first goal of this study was to examine whether participants' own popularity and acceptance are associated with their behavioral and neural responses to social exclusion. Although popular and accepted adolescents both show high social functioning, they might respond differently to exclusion. Accepted adolescents are highly sensitive to peer relationship problems (Hoglund, Lalonde, & Leadbeater, 2008), and report greater use of emotion-regulation strategies following rejection than less accepted adolescents (Reijntjes, Stegge, Terwogt, Kamphuis, & Telch, 2006). On the basis of these behavioral findings, it may be predicted that participants' acceptance would be positively associated with activation of brain areas implicated in the processing (i.e., dACC, sgACC, insula, mPFC)