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The neural correlates of dealing with social exclusion in childhood

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ABSTRACT

Observing social exclusion can be a distressing experience for children that can be followed by concerns for self-inclusion (self-concerns), as well as prosocial behavior to help others in distress (other-concerns). Indeed, behavioral studies have shown that observed social exclusion elicits prosocial compensating behavior in children, but motivations for the compensation of social exclusion are not well understood. To distinguish between self-concerns and other-concerns when observing social exclusion in childhood, participants (aged 7–10) played a four-player Prosocial Cyberball Game in which they could toss a ball to three other players. When one player was excluded by the two other players, the participant could compensate for this exclusion by tossing the ball more often to the excluded player. Using a three-sample replication (N = 18, N = 27, and N = 26) and meta-analysis design, we demonstrated consistent prosocial compensating behavior in children in response to observing social exclusion. On a neural level, we found activity in reward and salience related areas (striatum and dorsal anterior cingulate cortex (dACC)) when participants experienced inclusion, and activity in social perception related areas (orbitofrontal cortex) when participants experienced exclusion. In contrast, no condition specific neural effects were observed for prosocial compensating behavior. These findings suggest that in childhood observed social exclusion is associated with stronger neural activity for self-concern. This study aims to overcome some of the issues of replicability in developmental psychology and neuroscience by using a replication and meta-analysis design, showing consistent prosocial compensating behavior to the excluded player, and replicable neural correlates of experiencing exclusion and inclusion during middle childhood.

1. Introduction

Observing social exclusion occurs often in school-aged children and can be a distressing experience (Saylor et al., 2013). For example, when children observe that others are excluded from a game or social event, children may experience distress because they are concerned about their own inclusion, or they may feel the need to help the other person in distress, also referred to as prosocial behavior (Padilla-Walker and Carlo, 2014). Children show basic prosocial behavior from 18 months of age onwards (Warneken and Tomasello, 2006) and this behavior rapidly develops throughout childhood and adolescence when cognitive capacity and perspective taking skills continue to grow (Eisenberg et al., 2006; Güroğlu et al., 2014). However, the motivations for helping or compensation behavior remain largely unknown, possibly because these motives are difficult to unravel on the basis of behavior only. Neuroimaging may prove helpful to examine the different processes that take place when children observe social exclusion.

Social exclusion is often studied by using the Cyberball Game (Williams et al., 2000): a three player ball game where two virtual players no longer toss a ball to an excluded player, creating a situation of social exclusion. Although Cyberball is a computer game including virtual players, several studies have shown that both children and adolescents show more prosocial behavior in subsequent interactions towards individuals who have been excluded in this game, as indicated by helpful emails and money donations (Masten et al., 2010, 2011; Will et al., 2013). Recently a prosocial version of the paradigm was developed to examine concurrent compensating behavior when an individual is excluded (Riem et al., 2013). In the Prosocial Cyberball Game (PCG) participants can compensate for this exclusion by tossing the ball more often to the excluded player. Studies have shown that compensating behavior followed observed social exclusion towards the excluded player across childhood, adolescence and adulthood (Riem et al., 2013;

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van der Meulen et al., 2016; Vrijhof et al., 2016). Yet, it remains to be determined if children are most concerned about others when observing exclusion, or about self-inclusion and exclusion.

Neuroimaging research in adults revealed that simply observing another person being excluded is associated with increased activity in areas such as the dorsal anterior cingulate cortex (dACC) and bilateral insula (Masten et al., 2013; Meyer et al., 2013; Novembre et al., 2015). These regions are thought to play a role in social uncertainty and distress, and may be critically involved in experiencing concerns about self-exclusion (Cacioppo et al., 2013). Interestingly, previous studies have shown that the experience of being excluded yourself leads to feelings of decreased self-worth (Zadro et al., 2004), accompanied by an increase in activation of the dACC and bilateral insula (Cacioppo et al., 2013; Eisenberger et al., 2003; Rotge et al., 2015). Additionally, a recent study has added to this body of literature by postulating that co-activation in the dACC and bilateral insula is a measure of social inclusivity, and that activation in these two areas can therefore be found in both social exclusion and social inclusion contexts (Dalgleish et al., 2017).

In contrast, prosocial compensating behavior (i.e. compensating an excluded player) in the Prosocial Cyberball Game resulted in increased activation of the temporo-parietal junction (TPJ), nucleus accumbens (NAcc), and the bilateral insula (van der Meulen et al., 2016). The TPJ is an area previously associated with perspective taking (Carter and Huettel, 2013) whereas the NAcc is part of the reward network of the brain (Delgado, 2007; Lieberman and Eisenberger, 2009). Possibly, these regions play an important role in prosocial compensating behavior. These patterns of neural activity lead to the hypothesis that the Prosocial Cyberball Game might tap into two different processes: the experience or concern for possible self-exclusion and the compensation for exclusion of others. Experience of possible self-exclusion refers to the worry about own participation in the game, whereas compensation for exclusion is thought to reflect prosocial behavior.

The aim of the current study was to investigate the behavioral and neural correlates of reactions to observed social exclusion in middle childhood. Our target age was children in the age range 7–10 years because this is a critical age for forming intimate friendships and social connections (Buhrmester, 1990), but the neural reactions to observed social exclusion in this particular age range have not yet been studied. We used the Prosocial Cyberball Game (Riem et al., 2013) to study possible reactions to observed social exclusion, namely experience of possible self-exclusion and prosocial compensating behavior. Previous studies have called into question whether neuroimaging results survive Type I errors and may lead to too many false positives (Eklund et al., 2016). Moreover, recent projects have raised concerns about whether results from psychological experiments can be replicated (Open Science, 2015). Therefore, we used a replication approach including a pilot sample to generate hypotheses, a test sample to test these hypotheses, and a replication sample to confirm these findings. The test and replication sample consisted of co-twins because they are similar in many respects: this will optimize the chance for replication, and lack of replication cannot easily be ascribed to confounding or unmeasured differences between the two samples.

On a behavioral level we hypothesized that observing social exclusion would lead to prosocial compensating behavior (Riem et al., 2013; van der Meulen et al., 2016; Vrijhof et al., 2016). On a neural level we expected that both experiencing self-exclusion and self-inclusion would result in activity in dACC and bilateral insula (Cacioppo et al., 2013; Dalgleish et al., 2017; Eisenberger et al., 2003; Rotge et al., 2015). Furthermore, we expected that engaging in prosocial compensating behavior would lead to activity in dACC and bilateral insula (Masten et al., 2013, 2010) and TPJ, and NAcc, similar to what has been found in adults (van der Meulen et al., 2016). Although TPJ, dACC and bilateral insula show a sharp increase in cortical thickness during middle childhood (Mills et al., 2014; Pfeifer and Peake, 2012), not much is known about the functional role of these regions in observing social exclusion in middle childhood. The power of our experimental design suggests that the present set of studies is particularly sensitive to detecting brain-behavior relationships of higher socio-affective functions and their development in a developmental sample.

2. Materials and methods

2.1. Participants

Three samples were recruited for this study: a pilot sample, a test sample and a replication sample. The pilot sample consisted of 20 children aged 7–10 years (M = 8.13 years, SD = .97, 50% male). This sample was composed of 9 opposite sex twin pairs and 2 singletons, recruited from an existing database at Leiden University. The test and replication sample consisted of 30 same sex twin pairs (M = 8.19 years, SD = .68, 46.7% male). Co-twins in the twin pairs were randomly divided over the test and replication sample upon inclusion, such that one child from each pair was placed in the test sample and one child was placed in the replication sample. These participants were recruited for the longitudinal twin study of the Leiden Consortium on Individual Development (L-CID). Families with twin children aged 7–8 years at the moment of inclusion were recruited from municipalities in the western region of the Netherlands, by sending invitations to participate to their home addresses (obtained through the municipal registries).

Some participants were excluded from analyses due to excessive head motion during the MRI session or because they did not finish the scanning session (two children from the pilot sample, three children from the test sample, and four from the replication sample). The final pilot sample consisted of 18 children (M = 8.15 years, SD = 1.06, 55.6% male), the final test sample of 27 children (M = 8.23 years, SD = .67, 40.7% male), and the final replication sample of 26 children (M = 8.21 years, SD = .71, 42.3% male). The three samples did not significantly differ in age ($F(2, 68) = .04$, $p = .96$) or gender (X^2 (2) = 1.08, $p = .58$). All participants were screened for MRI contra indications, had normal (or corrected to normal) vision, were fluent in Dutch, and had no physical or psychological disorder that disabled their performance on the tasks. Written informed consent was obtained from both parents before the start of the study. Parents received €50 for the participation of their children, and all children received €3.50 and a goodie bag with small presents. The study was approved by the Dutch Central Committee on Research Involving Human Subjects.

2.2. Experimental design

To measure reactions to observed social exclusion we used an experimental fMRI adapted version of the Prosocial Cyberball Game (PCG) (Riem et al., 2013; van der Meulen et al., 2016; Vrijhof et al., 2016). In this game, participants see four classical Cyberball figures on the screen (Williams et al., 2000). The participant is represented by the figure at the bottom of the screen, and the three other figures are placed at the left, the right, and the top of the screen (see Fig. 1A). Participants were told that they were going to play a computerized ball tossing game with three other players. No mention was made of exclusion, in order to avoid influencing their behavior. Thus, prosocial compensating is not confounded with varying biases between participants to follow the explicit or implicit experimenter suggestions for desirable behavior. Participants were asked to imagine that they were actually playing the game by thinking about the setting and the other players of the game. Previous studies have shown that there were no differences in reduced feelings of belonging and self-esteem between conditions where participants believed that other players were present, or merely imagined that other players were present (Zadro et al., 2004). Since imagining playing with others is a strong manipulation in research on gaming (Konijn et al., 2007) and does not rely on deception, we also used this manipulation for the PCG.

The game consisted of two parts: the Fair Game and the Unfair