Social behavior in young twins : are fearfulness, prosocial and aggressive behavior related to frontal asymmetry?

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CHAPTER 3

Prosocial Owl Game: Assessing Compensation for Social Exclusion in Early Childhood

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Abstract

This study examined prosocial reactions to social exclusion in 4–6 year old children with a newly developed task: the Prosocial Owl Game (POG). In the POG, two cartoon owls exclude a third owl, and the child can compensate for this exclusion by giving the excluded owl the next turn. A replication design with two samples (both n = 214) consistently showed that the vast majority compensated for social exclusion in the first trials and that individual differences arise when the game progresses. Individual differences in the POG could not be explained by frontal asymmetry, parent-reported prosociality or donating behavior. However, substantial heritability estimates indicated that variance in the POG cannot be explained only by measurement error. The POG is a promising measure of prosocial compensating behavior in early childhood, but environmental influences on variation in POG performance need further investigation.

Keywords: Prosocial Owl Game, prosocial behavior, social exclusion, early childhood, frontal asymmetry, EEG

Introduction

On the playground children approach each other and invite their peers to play along. This type of behavior is considered prosocial behavior, or "any action that serves to benefit another person" (Schroeder & Graziano, 2015), in particular when the peer has previously been excluded from a game. Prosocial behavior may also have positive consequences for the actor in terms of social outcomes such as peer acceptance (Sebanc, 2000; Layous, Nelson, Oberle, Schonert-Reichl, & Lyubomirsky, 2012), mental health (Schwartz, Meisenhelder, Ma, & Reed, 2003), life-satisfaction, and academic achievement (Caprara, Barbaranelli, Pastorelli, Bandura, & Zimbardo, 2000; Caprara & Steca, 2005). In addition, experiencing social exclusion has negative consequences and is related to feelings of pain (Eisenberger & Lieberman, 2005) and aggressive behavior (Twenge, Baumeister, Tice, & Stucke, 2001). Prosocial individuals who are aware of the negative consequences of social exclusion for peers may be inclined to actively include an excluded peer and thereby compensate for social exclusion by others. Even though compensating behavior can be observed in children, studies objectively examining this specific kind of prosocial behavior in early childhood are lacking. In the current study we present a new task, the "Prosocial Owl Game" (POG), to measure prosocial compensating behavior in early childhood. The task is based on the Prosocial Cyberball Game, which has been used in older children, adolescents, and adults (Riem, Bakermans-Kranenburg, Huffmeijer, & van IJzendoorn, 2013; Vrijhof et al., 2016; Van der Meulen, van IJzendoorn, & Crone, 2016; Van der Meulen et al., 2017).

The development of prosocial behavior starts early in life, as even infants show helping or sharing behavior (Paulus, 2014). Factors that play an important role in the development of prosocial behavior are social-cognitive skills, differentiation between self and others, empathy, and moral reasoning (Paulus, 2014; Eisenberg, Spinrad, & Knafo-Noam, 2015). In general, prosocial behavior seems to increase from infancy to adolescence (Eisenberg et al., 2015). However, from the age of three children become more selective to whom they are prosocial based on friendships, gender and social rules (Hay & Cook, 2007). Individual differences in prosocial behavior may be associated with child temperament and environmental factors (e.g.

whether prosocial behavior is being probed or not). However, studies showed inconsistent findings concerning the relation between prosocial behavior and child temperament or environmental factors due to differences in context and type of prosocial behavior measured (Eisenberg et al., 2015). Thus far, the field has been unable to identify factors reliably characterizing children who show more prosocial behavior than others (Thompson & Newton, 2013; Eisenberg et al., 2015). Although the influence of situational factors, like probing or modelling, may contribute to the inconsistency of findings (Van IJzendoorn, Bakermans-Kranenburg, Pannebakker, & Out, 2010; Wildeboer et al., 2017), the lack of standard measurement tools may also be accountable for this state of affairs.

Prosocial behavior in early childhood is often assessed using questionnaires (e.g. parent or teacher reports) or in a variety of observational settings (e.g. helping, sharing or comforting; Paulus, 2018). Because parents and teachers may give socially desirable answers and are not constantly in the child's presence, reported prosocial behavior might not always converge with observed prosocial behavior (Wildeboer et al., 2017). Observations of helping, sharing, and comforting behaviors may be less biased, but are time consuming. Moreover, they are found to be only modestly related, probably because different tasks require different social-cognitive skills and motivations (Dunfield & Kuhlmeier, 2013). Furthermore, in the literature a distinction is made between costly and non-costly prosocial behavior. Prosocial behavior can be costly when the participant has to give up a possession, for instance in sharing tasks (i.e. money or stickers). Whether a child is inclined to share, and thus to show costly prosocial behavior, is influenced by the recipient's needs as well as the resource costs and the benefits for the participant (Martin & Olson, 2015). Prosocial behavior is non-costly in situations where the participant is helping or comforting without giving up any of his/her own possessions. Because of the limitations of existing measures, we developed an early-childhood version of an objective measure of non-costly prosocial behavior, enabling the examination of the development of prosocial behavior over time.

The Prosocial Cyberball Game (PCG; Riem et al., 2013) was developed to examine prosocial behavior in response to social exclusion. The task is based on the Cyberball Game, a virtual ball-tossing game with three players where, at a certain point in the game, two players no longer toss the ball to an excluded player (Williams & Jarvis, 2006). The PCG was adapted to a four-player game, including the participant and three unknown others. During the PCG the participants themselves were not excluded but they could choose to toss the ball to the player that was excluded by the two other players. Several studies have shown that from the age of seven onwards, individuals behave prosocially towards the excluded player by showing compensating behavior (i.e., tossing more than a third of their throws to the excluded player; Riem et al., 2013; Vrijhof et al., 2016; Van der Meulen et al., 2016, 2017). In adults, fMRI results showed increased activation in the temporal parietal junction, an area related to social reasoning and empathy (Decety & Lamm, 2006), and the nucleus accumbens, an area related to experiencing rewards (Lieberman & Eisenberger, 2009), during PCG compensating behavior (Van der Meulen et al., 2016). In 7-10-year-old children the posterior cingulate cortex/precuneus, an area related to empathy and mentalizing (Hyatt, Calhoun, Pearlson, & Assaf, 2015), was associated with prosocial compensating behavior. This suggests that social brain network areas related to empathy, rewards and mentalizing, are involved in compensating behavior during social exclusion.

The neural correlates of compensating behavior in early childhood have not been examined yet. We examined whether frontal asymmetry (FA), the difference between left and right frontal brain activity as measured with electroencephalography (EEG), is related to prosocial compensating behavior during social exclusion. According to the motivational direction model, FA is related to approach and withdrawal tendencies: relatively greater left activity reflects approach motivation and behavior whereas relatively greater right activity reflects withdrawal motivation and behavior (Harmon-Jones, Gable, & Peterson, 2010; Harmon-Jones & Gable, 2018). Showing prosocial behavior, for example by compensating for social exclusion, reflects a tendency to confront (rather than withdraw from) a situation and may be considered approach behavior toward the targeted individual. One study with infants (14-, 18- and 24-month-olds) indeed showed that greater left frontal activity was related to prosocial behavior in the form of understanding distress and global empathy for the mother in a behavioral comforting task (Paulus, Kühn-Popp, Licata, Sodian, & Meinhardt, 2013). Also, greater left frontal activity in adults was related to larger donations to charity, a form of costly prosocial behavior (Huffmeijer, Alink, Tops, Bakermans-Kranenburg, & van IJzendoorn, 2012).

Compensating behavior in reaction to social exclusion has thus far only been investigated in children of at least 7 years old, adolescents, and adults (Riem et al., 2013; Vrijhof et al., 2016; Van der Meulen et al., 2016, 2017). Knowledge about prosocial reactions to social exclusion on a behavioral and neural level in early childhood (4-6-year-olds) is still lacking. The current study examined this specific kind of prosocial behavior in early childhood by using a newly developed task, the "Prosocial Owl Game" (POG). We hypothesized that young children already notice social exclusion during a virtual game and can react prosocially by compensating for the exclusion. To check whether compensating behavior was related to other more conventional measures of prosocial behavior in early childhood we correlated the outcome of the POG with parental reports on social development and a donating task (observed costly prosocial behavior). However, because prosocial behavior is a multidimensional construct (Paulus, 2018; Padilla-Walker & Carlo, 2015), we had no strong expectations about these associations. Finally, we expected that greater left frontal activity at rest would be related to more prosocial compensating behavior, as we hypothesize that prosocial behavior is related to approach motivation. To validate the POG and replicate the findings within the current study, we used a twin sample to create two samples, a test and replication sample. This way we optimized the chance of replication because the two samples are equal in background variables like age and gender and similar in shared environmental factors. Thus, non-replication is not easily explained by differences between the samples. Furthermore, replication of false positives and noise is unlikely, and accordingly replicated outcomes are optimally reliable.

Methods

Participants

The participants in this study took part in the larger experimental longitudinal twin study of the Leiden Consortium on Individual Development (L-CID, Euser et al., 2016). Via municipal authorities in the western part of the Netherlands we recruited families with same-sex twins born between 2010 and 2013. Twins and their parents were included if they were fluent in Dutch and if the children were physically and mentally able to perform all tasks (see Euser et al., 2016 for more information on the recruitment procedure and full inclusion and exclusion criteria). Most children were living in families with a high (56%) or middle (37%) socioeconomic status (SES, based on the education level of the parents). Zygosity of the twins was determined by analyses of DNA samples collected by buccal swabs. When the DNA samples were missing (11%) zygosity was based on the zygosity questionnaire (Rietveld et al., 2000), which was filled out by the primary parent (the parent who spends the most time with the children). To create two independent groups we randomly assigned co-twins to either the test (sample A) or replication sample (sample B).

The final sample included 214 twin pairs, 59% monozygotic (MZ) and 41% dizygotic (DZ). Both test and replication samples consisted of 214 children (52% girls, *M* = 4.77 years, *SD* = 0.58, age range 3.86 – 6.54 years at the second wave of data collection). However, not all participants had valid data for all variables, therefore sample sizes vary somewhat for different analyses. For the POG, data were missing for seven children because they did not complete the task (test: n = 2; replication: n = 5). EEG data were missing for more children (test: n = 73, replication: n = 67), because of insufficient artifact-free EEG data (n = 50), technical problems (n = 29) or refusal to wear the EEG net (n = 61). Questionnaire data were missing for 12 children because the parents did not complete the questionnaires (test n = 6, replication n = 6), and donating data was missing when children did not complete the task (test n = 9, replication n = 10).

The local ethics committee and the Central Committee on Research involving Human Subjects in the Netherlands (CCMO; NL49069.000.14, Samen Uniek) approved of the study protocol. Informed consent was obtained for all participants prior to their involvement in the longitudinal study, for each twin both parents provided written informed consent. Families received a financial reimbursement after each visit and a small gift for the children.

Procedure

Participants took part in a longitudinal study with yearly visits. The current study includes data from the second wave of the data collection (n = 428 children). One week before the lab visit the parents received an e-mail asking them to complete online questionnaires, including the Strengths and Difficulties Questionnaire (SDQ; Goodman, Lamping, & Ploubidis, 2010) and the My Child Questionnaire (MCQ; Kochanska, DeVet, Goldman, Murray, & Putnam, 1994). The primary parent and the twins were invited for a lab visit with a total duration of approximately three hours. Each child was supervised by a research assistant who guided the child through the test session. Co-twins were randomly assigned to first complete either the block of behavioral tasks (including individual tasks and parent-child interaction tasks, results are presented elsewhere) or the block including EEG measures (including individual tasks, a resting baseline EEG measure and an EEG task measure). For the current study we used data from the resting baseline EEG measure only. Before starting the EEG measures the procedure was explained to parent and child. Next, the child was fitted with the electrode net. The EEG assessment consisted of a 3-minute resting baseline EEG measurement, followed by a task of approximately 15 minutes (see Van Wijk et al., 2017). After removal of the EEG-net, two behavioral tasks were performed, the Prosocial Owl Game and the Donating task.

Measures and Data Processing

Prosocial Owl Game. To measure prosocial behavior in response to social exclusion we used an adapted version of the four-player Prosocial Cyberball Game (PCG, Riem et al., 2013; Vrijhof et al., 2016; Van der Meulen et al., 2016, 2017). In our PCG version for early childhood the three virtual players used in the PCG are replaced with colorful cartoon owls, after which the game is called the "Prosocial Owl Game" (R. Damsteegt, Consortium on Individual Development, personal communication, March, 2015). The task consists of five stories in which owls are playing together in the playground: frisbee tossing, slide, ballgame, swing and spring rider (see Figure 1). The task has been programmed on a tablet and presents pictures with simple animations and audio instructions. The use of several playground stories helps the participants to remain motivated. The task starts with a fair game (frisbee tossing), in which none of the owls are excluded; all owls get equal turns. The next games are four exclusion games in which one owl is excluded and gets no turns from the other two owls. Each story consists of three trials and each trial shows three turns of the owls playing the game, in the fourth turn the participant can choose an owl to play next.

At the start of each story the three owls are introduced. Each story contains three different owls and they all have gender-neutral names consisting of four letters. In each story the excluded owl is shown at a different location (either in the middle, left or right of the screen) and with a different color to minimize the effect of the owl's location or color on any compensating behavior. The order of the exclusion stories was randomized between participants. Children were presented with four exclusion games, including three trials each, leading to a possibility to compensate in twelve trials. Compensating behavior was coded as 1 for each trial in which the participant chose the excluded owl to play. The duration of the task was approximately 10 minutes.

At the end of the task we asked two exit questions that could be answered with 'yes' or 'no'. The first question "Did you think the games were fair?" was answered by the child. The second question "Did the child notice the exclusion during the game?" was answered by the experimenter based on comments about the exclusion that the child had made during the game. Examples of comments that the children made during the game are "that owl did not receive the ball", "why is that owl not allowed to go on the swing?", or "that is not fair!". The experimenter coded these as evidence that the child noticed the exclusion of one of the owls during the game.

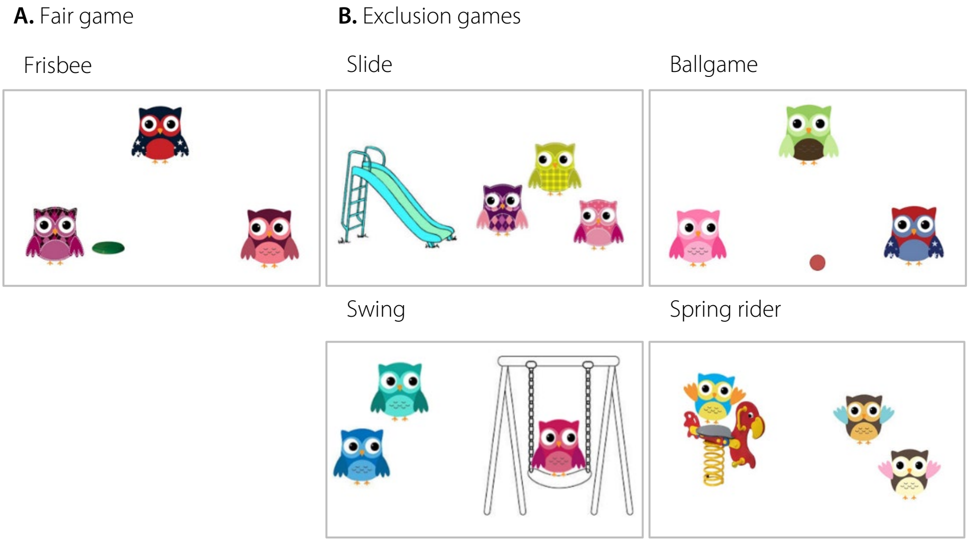

Figure 1. Prosocial Owl Game. (A) The first game is a fair game (frisbee tossing), in which none of the owls is excluded and they all get equal turns. (B) The next four games are presented in random order and consist of three exclusion trials were one owl is consistently (three turns) excluded and gets no turns. In all games the participants can pick an owl each fourth turn.

Donating task. Donating behavior was measured with an adapted version of the sharing task based on Knafo, Israel, and Ebstein (2011). After the POG, the participants received ten attractive stickers as a gift for doing well during the previous tasks, and an envelope. The experimenter explained to the child: "These ten stickers are for you. Tomorrow another child will visit the lab and perform the same tasks as you did today. However, that child does not get any stickers. You can decide to give stickers to the child who will visit us tomorrow. If you want to give stickers to the child who gets no stickers, you can put stickers in the envelope, and I will give the envelope to the child tomorrow. If you want to keep all the stickers for yourself then you can give me back an empty envelope. You may decide whether you give any stickers and if so, how many. I will check whether your brother/sister is done with the games in the other room and I will be back in a minute." After providing the instruction the experimenter left the room and kept an eye on the child via a live video that showed the room in which the child was. After one minute the experimenter went back to the child and asked “Are you ready with dividing the stickers? Can I have the envelope?”. The number of stickers in the envelope was counted after the lab visit, in absence of the child.

The distributions of the numbers of donated stickers in both the test and replication samples were severely skewed to the right. To obtain a more evenly distributed variable we distinguished three categories (comparable to Wildeboer et al., 2017): children who did not donate any stickers (sample A: 50%; sample B: 43%), children who donated less than half of all stickers (1-4 stickers; sample A: 24%; sample B: 26%), and children who donated at least half of all stickers (5-10 stickers; sample A: 26%; sample B: 31%).

Questionnaires. We used the following parent reports on prosocial behavior and empathy of the child. Both parents (primary and other parent) completed five items of the Prosocial scale of the Strengths and Difficulties Questionnaire (SDQ, Goodman et al., 2010) and 13 items of the subscale Empathic concern, the prosocial response to another’s distress, of the MyChild Questionnaire (MCQ, Kochanska et al., 1994). SDQ items were rated on a three-point scale ranging from *not true* (1) to *certainly true* (3). The MCQ had a five-point scale ranging from *untrue* (1) to *true* (5). The MCQ included an extra “not applicable” option when the behavior described in the item was not previously observed in the child, these items were coded as missing values and were not included in subscale scores. Some items were recoded in order to get higher scores reflecting higher levels of prosocial behavior or empathy.

We conducted a principal component analysis (PCA) on all 18 items completed by the primary parent and by the other parent in the test sample. Based on the scree plot and explained variance we identified two clear factors that together explained 36% of the variance. Two items from the MCQ (“May occasionally tease a pet if unsupervised” and “Feels good when good things happen to movie characters”) scored low on both factors (loadings of < .3), maybe because they are less age-adequate, and were removed from further analyses. Based on the content of the items we named the first factor "Empathy" (including for example SDQ item "Is helpful if someone is hurt") and the second factor "Contagion" (including for example MCQ item "Is upset by stories in which characters are hurt or die"). We followed the same procedure in the replication sample. The PCA showed that in this sample the same composition of items resulted in adequate factor loadings for the two factors *Empathy* and *Contagion*. The first factor 'Empathy' from the PCA included 11 items (see supplementary material, Table 1) and showed a good internal consistency in both samples (test: primary parent α = .84, other parent α = .85 and replication: primary parent α = .81, other parent α = .81). The second factor 'Contagion' included five items but one item ("My child seldom cries when seeing something sad on tv") had to be removed because it did not fit compared to the other items (internal consistency with five items was lower than .60). The second factor with four items (see supplementary material, Table 1) showed marginal internal consistency (test: primary parent α = .70, other parent α = .66 and replication: primary parent α = .61, other parent α = .63). For each factor a mean score across the items was computed for both primary and other parent and for the test and replication sample separately. Before computing mean scores, SDQ items were first transformed to the same scale (1 to 5) as the MCQ items. The data showed five outliers ($|z| < 3.29$; three in the test sample and two in the replication sample) that were winsorized (Tabachnick & Fidell, 2006). The correlations between the primary and other parent were all significant (test sample: Empathy $r = .48$; Contagion $r = .31$; replication sample: Empathy $r = .52$; Contagion $r = .25$, all $p < .01$). Therefore we computed mean scores based on both parent's ratings. When one of the parents did not fill out the questionnaires (n = 17 for the primary parent and n = 45 for the other parent) the score of the parent who did complete the SDQ and MCQ was used in further analyses. Both factors (Empathy and Contagion) were close to normally distributed and two outliers ($|z| < 3.29$, only in the replication sample) were winsorized (Tabachnick & Fidell, 2006).

Frontal EEG asymmetry. For the current study, we used the same procedure for data processing and analysis of the EEG data as previously described in Van Wijk et al., 2017. EEG was recorded during a 3-minute resting baseline. The child was instructed to alternatingly open and close his or her eyes for 30 seconds each (3x30 seconds eyes open and 3x30 seconds eyes closed). The computer played an audio message telling the child to close his/her eyes and displayed a drawing of closed eyes when the child had to close his/her eyes. After 30 seconds an audio message was played saying the child could open his/her eyes again. During the *eyes open* trials the child saw a color-changing dot on the screen to focus attention and avoid excessive eye-movements.

A 64-channel hydrocel geodesic sensor net and NetStation software (Electrical Geodesics, Inc.) with a NetAmps300 amplifier were used to record the EEG. To ensure a good signal each electrode was adjusted to keep impedances below 100 kΩ. To avoid fatigue, irritability and loss of attention in young children we minimized preparation time by adjusting and collecting data from only a subset of the electrodes (number in brackets): F3 [12], F4 [60], F7 [18], F8 [8], C3 [20], C4 [50], T7 [24], T8 [52], P3 [28], P4 [42], P7 [30], P8 [44], left [29] and right [47] mastoids, and two electrodes [62, 63] placed directly below the eyes. During recording the reference was Cz and data were low-pass filtered at the Nyquist frequency (i.e. 100Hz) for the sampling rate of 250 Hz.

After applying a 0.3 Hz high-pass filter (99.9% pass-band gain, 0.1% stop-band gain, 1.5 Hz roll-off) data were exported for further processing using Brain Vision Analyzer (BVA) 2.0 software (Brain Products, Inc). The EEG was low-pass filtered at 30 Hz (-3 dB, 48 dB/octave). The six 30-second trials were segmented into 2-second segments with 1-second overlap. Segments containing artifacts (i.e., segments in which the difference between the largest and smallest value was larger than 200 µV or in which the difference between the largest and smallest value within any 100 ms interval was smaller than 0.5 µV in any channel) were removed and bad channels were deleted from an individual dataset if the channel contained artifacts in more than 50% of segments. A fast Fourier Transformation (0.5 Hz resolution, 100% Hamming window) was used to compute power values (μV^2). Power values were averaged per condition over the artifact-free segments. The minimum requirement for a child's data to be included in further analyses was 28 segments per condition (equal to 56 seconds). On average 63 segments per condition were included (eyes closed: M = 61 [29 - 87]; eyes open: M = 65 [29 - 87]).

Power values were averaged across the frequency range of 6-10 Hz (alpha power in young children; Marshall, Bar-Haim, & Fox, 2002) to obtain alpha power for each condition. With a natural log transformation the data distributions were normalized. Frontal alpha asymmetry was computed by subtracting alpha activity over left frontal areas (electrode F3) from alpha activity over right frontal areas (electrode F4). The data showed seven outliers ($|z| > 3.29$) that were winsorized (Tabachnick & Fidell, 2006). There were 42 children with sufficient artifact-free EEG data for one condition only (eyes open n = 33 or eyes closed n = 9). To maximize the number of children in the analyses and because of the high correlation between the *eyes open* and *eyes closed* conditions ($r = .88$, $p < .01$), we estimated the value of the missing condition based on the value of the other condition using the regression equation obtained in the subsample of children with sufficient data for both conditions in the total sample (both test and replication sample, n = 246). Using this method, data of 42 children could be imputed and included in the analyses. Furthermore, because of the high correlation between the conditions *eyes open* and *eyes closed* we decided to average across the two conditions to obtain one value of FA per child, which we used in all subsequent analyses.

Data analyses

Preliminary analysis. Compensating behavior in the Prosocial Owl Game was analyzed using SPSS 23. First we checked whether the participants showed any systematic pattern of choice during the fair game by examining the percentages of expected and observed choices of each owl with chi-square tests. Next, we examined the pattern of compensating behavior during the exclusion games. Compensating scores per trial were summed over the four exclusion stories, leading to four variables: first, second, and third trial, and second and third trials combined. Monozygotic (MZ) versus dizygotic (DZ) within-twin correlations were computed to see whether compensating behavior may be influenced by genetic in addition to environmental factors, as higher MZ correlations than DZ correlations suggest genetic influences. To estimate heritability we computed Falconer's equations (Falconer & Mackay, 1996), with heritability defined as $h^2 = 2 \times (r_{MZ} - r_{DZ})$, in case of (non-significant) negative correlations we set the correlation to zero. In addition, we examined whether age, gender or SES were related to compensating behavior during the POG using respectively Pearson's correlations, independent samples t-tests and one-way ANOVAs, because of the potential confounding effect of these background variables.

Repeated measures and correlations. Differences in compensating behavior over the trials were investigated with repeated measures analysis of covariance (rmANCOVA). The results of the POG were correlated with FA to examine associations with approach-withdrawal tendencies as reflected by hemispheric differences in brain activity. Last, to examine whether compensating behavior was related to other prosocial behavior measures, POG compensating behavior was correlated with donating behavior and parent-reported Empathy and Contagion.

Results

Preliminary Analyses

Fair versus exclusion games. In the fair game we expected an equal chance of 33% for each owl to be chosen. Table 1 shows an overview of the observed percentages in the fair game in the test and replication samples. Chi-square tests revealed that there was no preference for a specific owl during the fair games in the test sample in the first or third trials ($p > .05$), but there was a small preference for the left owl in the second trial ($\chi^2(2) = 6.24$, $p = .04$). In the replication sample there seemed to be a small preference for the middle owl in the first trial ($\chi^2(2) = 6.47$, $p = .04$), whereas the second and third trials did not show a preference for a specific owl ($p > .05$). Overall, we concluded that the data showed no systematic pattern of choice during the fair game. In the exclusion games, participants showed a clear preference for the excluded owl, see Table 2. We summed the choices of the children for each owl (the excluded owl and the other two owls) over the games and chi-square tests confirmed that participants chose the excluded owl more often than expected by chance (test: χ^2 *(2)* [158,54 – 694,43], p < .01; replication: χ^2 *(2)* [140,97 – 743,91], p < .01). This preference for the excluded owl indicated that the children showed prosocial compensating behavior. Especially during the first trial, the vast majority of the children (73 – 81%) showed compensating behavior, indicating low variance in compensating behavior between individuals on the first trials.

Twin correlations. Because the first trials of the POG did not show much variance between the children, we did not compute within-twin correlations for the first trials. In the second and third trials MZ twin correlations were more than twice as large as DZ twin correlations (second trial: r_{MZ}= .30, p < .01; r_{DZ} = -.06, p = .59, h^2 = .60); third trial: r_{MZ}= .38, p < .01; r_{DZ} = -.01, p = .92, h^2 = .76), which suggests a substantial genetic influence on compensating behavior. We also computed a variable that combined the second and third trials (with a compensation score ranging from 0-8). As expected, MZ twin correlations were more than twice as large as DZ twin correlations and the heritability estimate was large (r_{MZ}= .49, p < .01; r_{DZ} = -.07, p = .56, h^2 = .98).

Table 1. Pattern of chosen owls during Fair Game in percentages.

Sample	Trial	Owl A	Owl B	Owl C	χ^2
Test	1	26	39	38	5.02
	2	27	32	41	6.24*
	3	39	32	29	3.58
Replication	1	26	44	33	6.47*
	2	28	35	36	2.48
	3	37	29	34	2.19

Note: chi-square test shows differences between observed versus expected (i.e. 33%, equal distribution between owls) values. ** p < .01; *p < .05

Table 2. Pattern of compensation behavior (percentages of choosing the excluded owl).

Sample	Trial	Game 1	Game 2	Game 3	Game 4
Test	1	76	81	73	73
	2	52	55	53	53
	3	50	60	55	52
Replication	1	81	74	79	77
	2	47	57	57	50
	3	59	51	57	57

Exit questions. At the end of the POG we asked the children whether they thought the games were fair. The majority of the children responded with 'yes' (test: 57%; replication: 53%), about one-third of the children responded with 'no' (test: 30%, replication: 33%). Data were missing for the rest of the children. Independent samples t-tests showed that there were no significant differences in compensating behavior between children who did or did not think the games were fair (test: $t(203)$ = [-0.89 - 0.97, ps > .05, replication $t(202)$ =[0.24 - 1.51, ps > .05). Approximately half of the children spontaneously mentioned the exclusion during the game (test: 47%, replication: 47%). The other children did not comment on the exclusion. When the child mentioned the exclusion during the task, the child compensated significantly more in the second trial (test: $M = 2.4$, $SD = 1.6$; replication: $M = 2.3$, $SD = 1.3$) compared to children who did not comment on the exclusion (test: $M = 1.9$, $SD = 1.3$; replication: $M = 1.9$, $SD = 1.2$; test: t (210) = -3.02, $p < .01$, replication: t (207) = -2.66, $p < .01$). This effect was not found in the first or third trials (ps > .05).

Gender, age and SES. No gender difference was found in the second or third trial (test and replication: all $p > .05$, d = [0.01 – 0.17]). However, boys and girls were significantly different in their compensating behavior during the first trial ($t(210) = -2.46$, $p < .05$, $d = 0.34$); girls compensated more ($M = 3.19$, $SD = 0.93$) than boys ($M = 2.87$, $SD = 0.96$) in the test sample, but not in the replication sample. Older children showed more compensating behavior than younger children in the second trial, but only in the test sample ($r = .23$, $p < .01$, all other $r \leq .13$, $ps > .05$). In both samples, parental SES was not related to compensating behavior (F (2, 210) = [0.17 – 2.29], $ps > .05$, η_p^2 = [.00 – .02]). Based on these results, we included gender and age as covariates in the rmANOVA and in the correlations with other prosocial measures.

Repeated Measures and Correlations. Results of the rmANCOVA showed a main effect of trial in both the test and replication sample (test: $F(2,211) = 54.42$, $p < .01$, $\eta_p^2 = .21$; replication: $F(2,208) = 60.22$, $p < .01$, $\eta_p^2 = .23$). Planned post hoc pairwise comparisons showed that children compensated significantly more in the first trial (test: $M = 3.04$, $SD = 0.95$; replication: $M = 3.11$, $SD = 0.99$) than in the second (test: $M = 2.15$, $SD = 1.25$; replication: $M = 2.11$, $SD = 1.29$, $p < .01$) and third trial (test: $M = 2.16$, $SD = 1.17$; replication: $M = 2.24$, $SD = 1.08$, $p < .01$), see Figure 2. No significant difference was found between the second and third trial ($p = 1.00$). On the contrary, these trials were significantly correlated (test: $r = .25$, $p < .01$, replication $r = .34$, $p < .01$), which supports their combination into one POG score.

The outcomes of the POG were not related to frontal asymmetry (all $r < .15$, $p > .05$) or to other measures of prosocial behavior (donating and parent-reported Empathy and Contagion, $rs < .15$, $ps > .05$), see Table 3 for an overview of the correlations.

Table 3. Partial correlations (including covariates gender and age), mean scores and standard deviations for all variables.

	1	2	3	4	5	6	7	8	M	SD
1 POG trial 1		.03	.22**	.15*	-.04	.11	.00	.11	3.11	0.99
2 POG trial 2	.10		.34**	.85**	.06	.01	-.02	.10	2.11	1.29
3 POG trial 3	.26**	.25**		.78**	.01	.00	-.01	-.03	2.24	1.08
4 POG trial 2+3	.22**	.80**	.78**		.04	.00	-.02	.05	4.35	1.94
5 Donating behavior	-.01	-.01	.09	.05		-.04	.01	.07	1.89	0.86
6 Reported empathy	-.02	-.11	-.10	-.13	-.01		.20**	-.04	4.18	0.56
7 Reported contagion	.05	.00	-.04	-.02	-.04	.29**		-.03	2.87	0.79
8 Frontal asymmetry	-.06	.02	.13	.09	-.17*	-.03	-.08		-0.11	0.23
M	3.04	2.15	2.16	4.31	1.76	4.24	2.92	-0.09		
SD	0.95	1.25	1.17	1.92	0.84	0.53	0.80	0.24		

Note. Correlations for the test sample are presented below the diagonal, and correlations for the replication sample are presented above the diagonal. Means and standard deviations for the test sample are presented in the horizontal rows and for the replication sample in vertical rows. Sample size for variables 1 - 7 ranged from 204 – 212, sample size for frontal asymmetry were: test: n = 141; replication: n = 147. ** *p* < .01; **p* < .05

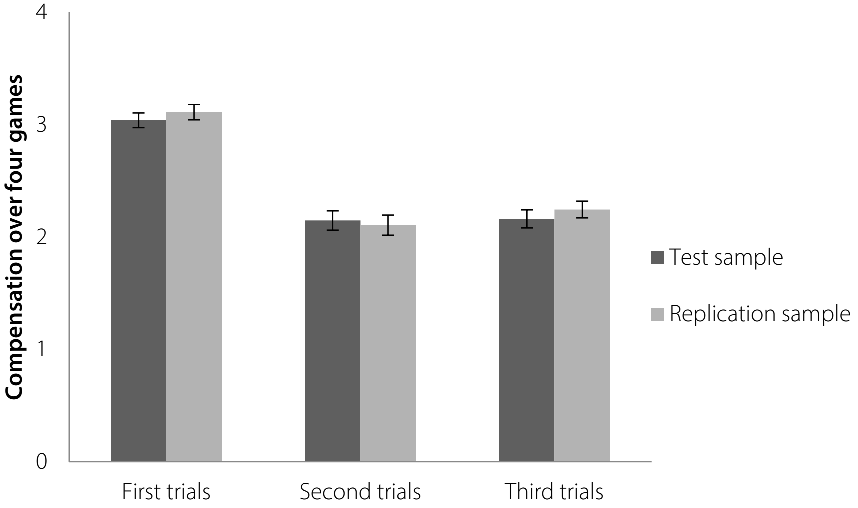

Figure 2. Compensating behavior (amount of choosing the excluded owl). In both test and replication sample children compensate more in the first trial compared to the second and third trial per game (*p* < .001; error bars represent standard errors).

Discussion

The current study examined compensating behavior in reaction to social exclusion in 4 – 6-year-olds by using a newly developed task: the Prosocial Owl Game (POG). In line with previous studies using the Prosocial Cyberball Game (PCG; Riem et al., 2013; Vrijhof et al., 2016; van der Meulen et al., 2016, 2017), results showed that in general children respond prosocially after social exclusion by choosing the excluded owl more often than expected by chance. During the first trials children compensated significantly more often than during the second and third trials – in fact there was not much inter-individual variance in responses at the first trials, indicating that the exclusion of one of the owls had been (consciously or unconsciously) registered. There was more individual variability in compensating behavior in the second and third trials, implying that individual differences only appear later in the game. FA was not related to compensating behavior during the POG and neither were parent-reported prosocial behavior or observed donating behavior. Results were similar in the test and replication sample.

The goal of the POG was to measure prosocial compensating behavior in response to social exclusion. On the first trial of each game we found little variance between the children, the majority of children showed compensating behavior by choosing the excluded owl. When the game progressed, there was more variation between the children in their compensating behavior as a smaller proportion of children compensated for the social exclusion in the second and third trials. Variation in the second trial was related to whether or not the children mentioned the social exclusion during the POG. Children who spontaneously said something about the exclusion during the game showed more compensating behavior in the second trial than children who did not mention the exclusion. These children might have been surprised that the social exclusion by the other players continued and responded both verbally and behaviorally by including the excluded owl in the game. However, individual differences in the third trial could not be explained by whether or not the children mentioned the social exclusion. Overall, our findings suggest that more than one trial is necessary to elicit individual differences in prosocial behavior. This is in line with a recent meta-analysis on the relation between the observability of a prosocial act and the degree of displayed prosocial behavior, which showed that there was a stronger positive effect on observable prosocial behavior when the measurement was repeated compared to a single measurement (Bradley, Lawrence, & Ferguson, 2018). Related to this, both the second and the third trials of the POG showed stronger MZ correlations than DZ correlations for compensating behavior, suggesting heritability of prosocial compensating behavior, which is in line with the results of other studies on prosocial behavior (Knafo-Noam, Vertsberger, & Israel, 2018).

Individual differences in compensating behavior during the POG could not be explained by gender or age. Age was only related to compensating behavior in the second trial of the test sample (older children compensated more), but this effect was not found in the replication sample. However, the age range was quite small, and age-related effects might occur over a broader age range. Although gender and age effects were not replicated, we did correct for gender and age in further analyses as other studies investigating prosocial behavior found inconsistent results as well. A review by Rose and Rudolph (2006) showed that gender differences, in favor of girls, are mostly found when subjective measures of prosocial behavior are used (either self-, peer- or teacher reports). In addition, observational studies indicated that these gender differences seem to become more consistent with age (Rose & Rudolph, 2006). Some argue that stereotypic gender roles affect the findings on gender differences in subjective measures of prosocial behavior, as girls are generally expected to be more prosocial than boys (Eisenberg et al., 2015). With regard to compensating behavior, previous research with adolescents did not find gender or age effects on the PCG (Vrijhof et al., 2016), suggesting that compensating behavior in reaction to social exclusion is less influenced by expectations and might be a more valid measure of prosocial behavior across ages and gender.

Compensating behavior in reaction to social exclusion was not related to FA. Also, FA was unrelated to parent-reported Empathy and Contagion and observed donating behavior. Some other studies involving infants (Paulus et al., 2013) and adults (Huffmeijer et al., 2012) reported an association of relatively greater left frontal brain activity with prosocial behavior. The alpha frequency band, underlying FA, is subject to developmental changes (Saby &

Marshall, 2012), and this may account for different results in studies on different age groups. In children the estimates of the appropriate alpha frequency bandwidth (progressing from 6 – 9 Hz in infancy to 8 – 12 or 13 Hz in late adolescence and adulthood) are based on developmental changes in peak frequencies (Marshall et al., 2002). However, empirical studies proving that the 6 – 10 Hz frequency band indeed represents deactivation of cortical tissue and is thus inversely related to relatively greater brain activity in young children are lacking. As mentioned previously (Van Wijk et al., 2017), studies examining the development of the EEG frequency composition, 'alpha' bandwidth, and FA in children are thus badly needed.

Compensating behavior during the POG was not related to the other, more conventional measures of prosocial behavior. Although such associations would point to convergent validity of the measure, the absence of such associations does not indicate a lack of validity. Empirical studies have repeatedly shown that prosocial behavior is a multidimensional construct, and that outcomes are dependent on the context and on the type of prosocial behavior measured (Paulus, 2018; Padilla-Walker & Carlo, 2015). As a consequence, other studies failed to find associations between different prosocial responses in infants as well (Dunfield, Kuhlmeier, O'Connell, & Kelley, 2011; for a review see Thompson & Newton, 2013). In addition, compensating behavior during the PCG was not related to self-reported prosocial behavior in adolescents (Vrijhof et al., 2016) or self-reported empathy in adults either (Van der Meulen et al., 2016). The fact that we obtained substantial heritability estimates for prosocial POG behavior indicates that results do not merely reflect measurement error. Further research is necessary to explain exactly what factors underlie individual differences in prosocial compensating behavior.

Our study has some limitations that could also be addressed in future studies. First, the external validity of the POG should be further investigated. In general laboratory tasks are under debate because it is difficult to ensure that findings obtained using experimental tasks in laboratory settings are generalizable to real life situations (e.g., Winking & Mizer, 2013). The POG is based on the PCG which in turn is a variant of the classic Cyberball game. Cyberball is based on a real life experience (Williams & Jarvis, 2006) and even when participants know that they are being excluded by a computer instead of real-life players they still feel ostracized (Zadro, Williams, & Richardson, 2004). In addition, online social exclusion shows similar results as in-person social exclusion (Filipkowski & Smyth, 2012), which may be considered as support for the external validity of Cyberball. During the POG the children noticed the social exclusion, similar to Cyberball. Like the PCG, the POG included the possibility for the child to compensate for the exclusion. More research is necessary to ensure that compensating behavior during computerized games is similar to real-life prosocial compensating behavior. Second, about 44% of the children provided no usable FA data (test: n = 73, replication: n = 67), an attrition rate that is common in EEG research with young children (Bell & Cuevas, 2012). Future studies should search for ways to improve the quality and quantity of EEG data in early childhood.

We also point out some significant strengths of the study. First, our newly developed task has several advantages compared to other prosocial measures. Other observational tasks often use actors in order to provoke helping, sharing or caring behavior. Minor differences in acting or physical appearance of the actor might influence the behavior of the child. Therefore we standardized the procedure of the POG by programming the game on a tablet with animations and audio instructions to create a more objective task that requires minimal involvement of the experimenter. In addition, we randomized the position and color of the excluded owl which ensured that symmetry (e.g. Vrijhof et al., 2016) or color preferences of the participant did not influence compensating behavior. Hence, we suggest that the POG is an objective and feasible task to measure non-costly prosocial compensating behavior in reaction to social exclusion. Second, we used a replication design. The importance of replicability has been a hot topic lately because of the need to find a way to overcome bias and error in science (Pashler & Wagenmakers, 2012). In our study we used matched twin samples and showed that most outcomes were replicated, indicating that the outcomes of the POG are consistent and reliable. The test and replication sample were created by randomizing each co-twin to one of the two samples. This procedure optimizes replication because the two samples are similar in age, gender and family background. Another advantage of the twin sample was that we could compute within-twin correlations to indicate genetic influences on prosocial compensating behavior.

In conclusion, the current study showed that 4 – 6-year old children compensated for social exclusion in the “Prosocial Owl Game” task. The vast majority of children showed compensating behavior in the first trial of each game and individual differences emerged in the second and third trial of each game. Individual differences in prosocial compensating behavior could not be explained by FA, parent-reported prosocial behavior or observed donating behavior of the child. Future research should examine factors that influence prosocial compensating behavior in reaction to social exclusion. The high MZ correlations compared to DZ correlations of the POG suggest that genetic factors play a role. This study shows that the POG can be used to measure prosocial compensating behavior in young children in a similar way as the PCG is used with older children, adolescents and adults (Riem et al., 2013; Vrijhof et al., 2016; van der Meulen et al., 2016, 2017). The POG therefore facilitates developmental studies of prosocial compensating behavior across ages and with longitudinal designs.

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