Hanging out with the right crowd : behavioral and neuroimaging studies of peer influence on decision-making in adolescence

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Chapter 5:

Peer influence on prosocial behavior in autism

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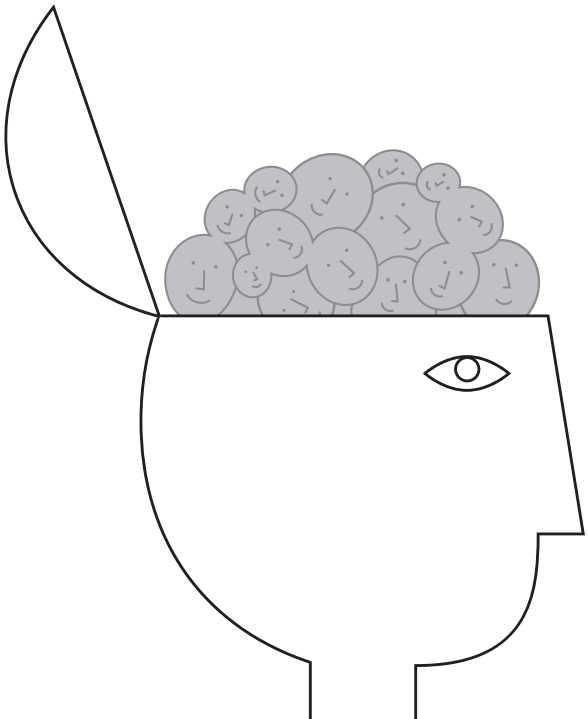

Abstract

Peer influence has a profound impact on decision-making in typically developing (TD) adolescents. In this study, we examined to what extent adolescents (age eleven-seventeen years; $N = 144$) with and without autism (ASD) were influenced by peer feedback on prosocial behavior, and which factors were related to individual differences in peer feedback sensitivity. In a public goods game, participants made decisions about the allocation of tokens between themselves and their group – in the absence or presence of peer feedback. ASD and TD adolescents were sensitive to peer feedback on prosocial behavior. More autism traits and social interest were associated with less sensitivity to antisocial feedback. These results suggest that peer feedback creates opportunities for social adjustment in ASD and TD adolescents.

1. Introduction

For most high-functioning individuals with autism spectrum disorders (ASD), challenges in the social domain are the most disabling aspect of the disorder (Lai, Lombardo, & Baron-Cohen, 2014; Travis & Sigman, 1998). These social difficulties grow more pronounced when children transition into adolescence, as the social world becomes increasingly focused on the peer group (Carter et al., 2014; Nelson, Jarcho, & Guyer, 2016). A large body of literature acknowledges peers as a powerful source of socialization in typically developing (TD) adolescents (Albert, Chein, & Steinberg, 2013; Brechwald & Prinstein, 2011). Despite the negative connotations of peer influence, emerging evidence points to relations with positive psychosocial outcomes, such as increased prosocial behavior (Van Hoorn, Fuligni, Crone, & Galván, 2016). However, it is currently unclear to what extent adolescents with ASD are influenced by their peers – for better or for worse. The current study aims to examine the effects of peer influence on prosocial decisions of adolescents with and without ASD.

Peer influence in adolescence

Peer influence is often associated with direct pressure to adjust behaviors or attitudes to the group (Brown, Bakken, Ameringer, & Mahon, 2008). However, common modes of influence also include behavioral display and reinforcement of displayed behavior by valued peers (Bandura, 1986). Through peer influence adolescents acquire social norms that specify unwritten rules for approved social behaviors in the peer context (McDonald & Crandall, 2015). Social norms as well as their perception can drive behaviors and attitudes, especially

when situations are novel or uncertain (Berger, 2008; Cialdini & Trost, 1998). For example, the *mere presence* of peers increases risky driving in adolescence (Albert et al., 2013) and such an increase may be guided by the individual's perception of the social norms in the peer group. Additionally, risk-stimulating *peer feedback* leads to more risky driving behavior in adolescents than peer feedback that is risk-averse (Simons-Morton et al., 2014). Prosocial behaviors such as cooperation and intentions to volunteer are similarly influenced by peer feedback (Choukas-Bradley, Giletta, Cohen & Prinstein, 2015; Van Hoorn, Van Dijk, Rieffe, Meuwese, & Crone, 2016). Changes in cooperation depend on which type of behavior is endorsed by a peer group (Van Hoorn et al., 2016b). When peers value decisions to donate tokens to the group (i.e., prosocial feedback), cooperative choices increase. On the other hand, when peers value decisions to keep tokens to the self (i.e., antisocial feedback), adolescents show a decrease in cooperative choices. These results implicate that peer feedback provides an opportunity for social adjustment learning in typical development (Van Hoorn et al., 2016b).

Like TD adolescents, those with ASD develop increased orientation to peers (McGovern & Sigman, 2004). However, adolescents with ASD often struggle with navigating social situations in the peer context (Tantam, 2003). Given the nature of social difficulties in ASD, it may be that ASD adolescents show an attenuated sensitivity to peer influence as compared to TD. One study investigated conformity using a child-friendly version of the classic Asch paradigm in children (age seven to eleven) with and without ASD (Yafai, Verrier, & Reidy, 2014). In this task children were asked to indicate which one of three sample objects was the same size as the stimulus object - and were presented with incorrect information by the experimenter ("most people think…"). Children with ASD conformed less to the opinion of others than TD children, and more autism traits were negatively related with the likelihood to conform in the TD sample.

In the domain of prosocial behavior, TD adults have been found to donate more money to charity when observed by peers, whereas adults with ASD donated the same amount regardless of the presence of an observer (Izuma, Matsumoto, Camerer, & Adolphs, 2011). Collectively this work suggests that children with ASD conform less to social pressure from adults, and adults with ASD are less sensitive to the presence of other people than their TD counterparts. Yet, it is unknown whether adolescents with ASD are sensitive to feedback from *peers*, during a developmental period in which the peer context is crucial for development (Nelson et al., 2016).

Moreover, individual differences exist in the extent to which both TD and ASD adolescents interact with their social environment (McGovern & Sigman, 2004; Steinberg & Monahan, 2007). A key factor in differential sensitivity to peers may be social interest - the motivation to engage with one's social world (Chevallier et al., 2012). In TD adolescents, individual differences are reported in the desire for friendship (Richard & Schneider, 2005). As a result, those with a high desire for relationships with peers may be more influenced by their peers than those with low social interest. While individuals with ASD show less social interest, individual differences within the spectrum are acknowledged with regards to social impairments, and potentially also social interest (Chevallier et al., 2012; Jones & Klin, 2009; Sedgewick, Hill, Yates, Pickering, & Pellicano, 2016). For example, in adolescents with ASD the extent to which individuals are socially engaged predicts adaptive social behavior (McGovern & Sigman, 2004). These individual differences across groups imply that it is essential to complement a between-groups approach (ASD-TD) with a continuous approach (investigating autism symptoms in the total sample) to investigate sensitivity to peer feedback and the role of social interest in this process.

Present study

The main goal of this study was to investigate to what extent boys (aged eleven to seventeen years) with and without ASD are influenced by peer feedback on prosocial behavior, and whether social interest may play a role in individual differences in peer feedback sensitivity. We focused on this specific age range because peer influence is highly salient during adolescence (Albert et al., 2013). Only boys were included because they represent the largest part of the ASD population with a ratio of 4.5:1 to girls (CDC, 2014). To achieve this goal we used a previously validated paradigm called the peers public goods game (PGG), in which participants had to make decisions about the allocation of tokens between themselves and their group (see Van Hoorn et al., 2016b). The number of tokens donated to the group in the PGG is a measure for prosocial behavior (Penner, Dovidio, Piliavin, & Schroeder, 2005). Although giving to the group for the benefit of others is not necessarily altruistic behavior, it represents an important aspect of prosocial behavior (Batson & Powell, 2003).

We examined peer influence by having the participants complete the task under different conditions. Participants made prosocial decisions in a group while online age-matched spectators were present who provided feedback (Feedback condition), with spectators present but no feedback (Spectators condition) and without spectators (Alone condition). We used a between-subjects design to compare two types of feedback on prosocial behavior, similar to Van Hoorn et al (2016b). In the Prosocial Feedback condition, the

spectators valued prosocial decisions (i.e., donations to the group), but not selfish decisions (i.e., keeping tokens to the self). In the Antisocial Feedback condition, this was the exact opposite, as peers valued selfish decisions, but not prosocial decisions.

More specifically, the first aim of the current study was to compare the sensitivity to peer feedback and its effect on prosocial behavior in adolescent boys with and without ASD. We hypothesized that boys with ASD would be less sensitive to peer influence on prosocial behavior than TD boys (Izuma et al., 2011; Yafai et al., 2014). Our second aim was to examine whether in the *total sample* the severity of autism symptoms and social interest (indices: social reward sensitivity, resistance to peer influence) were related to peer feedback sensitivity. We expected that boys with fewer autism symptoms and higher social interest would be more sensitive to peer feedback (Richard & Schneider, 2005; McGovern & Sigman, 2004).

2. Method

Participants

The total sample consisted of 144 adolescents between the age of eleven and seventeen years ($M = 14.83$, $SD = 1.40$, range 11.50 – 17.58), including 75 boys with ASD (52%) and 69 typically developing boys (48%). Before the start of the study, the institutional review board approved all procedures and consent was obtained from participants and their parents. The majority of the ASD group was recruited from a specialized school for adolescents with autism and a normal intelligence ($N = 71$), whereas another 4 ASD participants were recruited together with TD participants from a regular high school. School admission criteria included a normal intelligence (IQ $>$ 80) and a clinical ASD diagnosis according to the *Diagnostic and Statistical Manual of Mental Disorders – Fourth Edition* (DSM-4, American Psychiatric Association, 2000). The diagnoses were established before the start of the study by independent child psychiatrists and psychologists and retrieved from school files. Given the spectrum approach in the DSM-5, we did not make a distinction between autism subtypes in the current study (DSM-5; American Psychiatric Association, 2013). Parent-reported scores on the Social Responsiveness Scale (SRS) ($N = 125$; $N = 19$ missing) confirmed symptoms for the last 6 months with scores in the clinical range (SRS $>$ 60) for the ASD group but not for the TD group, $t(123) = -15.87$, $p < .001$ (Roeyers, Thys, Druart, De Schryver & Schittekatte, 2012). Comorbid psychiatric disorders were reported for 24% of the ASD group including 17% AD(H)D, 4% DCD, 1% OCD, 1% Gilles de la Tourette; and another 4% was unknown.

The TD group was recruited from three regular high schools teaching several academic levels in the Netherlands and matched the ASD group on education level. Psychiatric disorders were reported in 3%, specifically ADD and ADHD; 82% reported no disorders and information was missing for an additional 15% because parent questionnaires were missing. Further background information about the sample can be found in Table 1.

Table 1. *Participant characteristics ASD group and TD group*

	ASD ($N = 75$)	TD ($N = 69$)
Age (*SD*)	14.75 (1.46)	14.91 (1.33)
Range	11.50 – 17.42	12.58 – 17.58
Total IQ (*SD*)	116.53 (10.20)	105.48 (9.48)**
Range	90 - 137	83 – 130
Autism symptoms SRS (*SD*)	83.82 (24.87)	26.86 (12.15)**
Range	38 - 141	6 – 55
Verbal understanding CELF (*SD*)	10.51 (2.31)	10.48 (2.58)
Range	6 - 15	5 - 15
Interpersonal competence (*SD*)	4.51 (0.61)	5.33 (0.58)**
Range	2.97 – 6.07	3.37 – 6.47
Country of birth: Netherlands	94%	93%
Other	6%	7%
Treatment	77%	0%
Medication	39%	1%
Parental income[1]	ASD ($N = 54$)	TD ($N = 49$)
Lower income	46%	29%
Middle income	19%	20%
Upper income	35%	51%
Parental education[2]	ASD ($N = 69$)	TD ($N = 60$)
Primary education	0%	2%
High school	6%	0%
Vocational training	22%	15%
Professional training	38%	38%
University – college	12%	5%
University – master	17%	37%
Other	6%	3%

** $p < .001$, * $p < .05$ *Note.* CELF = Clinical Evaluation of Language Fundamentals®–Fourth Edition (CELF®-4), subtest Understanding Spoken Paragraphs. Treatment = social skills training, psycho education or more specific training such as anger regulation. Medication = methylphenidate (restlessness) or risperidone (behavioral problems). Parent-rated interpersonal competence scores (ICS; Cairns, Leung, Gest, & Cairns, 1995) were collected from $N = 67$ parents in ASD group and $N = 58$ parents in TD group.

[1] Income below €30,000 is classified as lower income, middle income between €30,000 and €40,000 and income higher than €40,000 is classified as upper income. For two-parent families the parent with the highest income is reported. [2] For two-parent families the parent with the highest educational degree is reported.

To test for possible confounding group differences, we obtained IQ scores for intelligence and used the subtest "Understanding Spoken Paragraphs" of the Clinical Evaluation of Language Fundamentals (CELF) as an indication of verbal language comprehension (Semel, Wiig, & Secord, 2003). Full IQ scores for $N = 70$ were collected from school files for the ASD group ($N = 5$ missing). We administered the subscales Similarities and Block Patterns

from the Wechsler Intelligence Scale for Children (WISC-III; participants < 16 years) and Wechsler Intelligence Scale for Adults (WAIS-III; participants 16 years and older) to obtain an estimate of IQ in the TD group. Estimated IQ scores were obtained for $N = 64$ ($N = 5$ missing). The estimated IQ scores fell within the normal range for all participants and were higher in the ASD group than TD group ($t(132) = -6.48$, $p < .001$). This discrepancy between education level and IQ has been documented before and may be due to the ASD symptomatology (Estes, Rivera, Bryan, Cali, & Dawson, 2011).

Participants were assigned to the two feedback conditions in a semi-random manner, with $N = 37$ (26%) in the ASD prosocial feedback condition, $N = 35$ (24%) in the TD prosocial feedback condition, $N = 38$ (26%) in the ASD antisocial feedback condition, and $N = 34$ (24%) in the TD antisocial feedback condition.

Experimental task

Peers public goods game. Participants played the peers public goods game (PGG), an adapted version of the economic game in which prosocial behavior is operationalized as cooperation to benefit one's group (see Van Hoorn et al., 2016b). Participants were led to believe that they would connect online to a group consisting of three other anonymous age-matched group members. In fact, participants played the task individually and there were no other players. They were told that they had to make anonymous and independent decisions in this group of four peers and that their group would get the opportunity to earn a monetary bonus. Each round, participants received five tokens with an exchange value of 50 Eurocents per token. Then, they made a decision whether they wanted to keep any amount of the tokens to themselves or contribute to their group by giving tokens to the public goods pot. Giving to the public goods pot was beneficial to the group, because all donated tokens were multiplied by two and divided equally amongst the 4-person group, independent of the respective contributions. Importantly, anonymity of decisions was guaranteed as participants could not see the decisions of fellow group members, nor could these other group members see the participants' decision. This was done to ensure that participants made their choices individually, rather than learning from the decisions of the group members. For a more extensive background of the PGG, we refer to Van Hoorn et al. (2016b).

The PGG consisted of thirty trials divided over four conditions (see Figure 1A). First, participants played five *Alone* trials (trials 1 – 5), during which decisions were made individually within the group. Each trial started with a fixation screen presented for 500

ms, followed by the stimulus screen (5000 ms) during which participants had to make their decision. Subsequently a waiting screen was displayed with a random presentation time between 2000 and 4000 ms, which displayed the text "Waiting until other players made their decision" (see Figure 1B for all screens and display times).

Second, participants were told that a spectator group of five same age peers would be online during the next ten *Spectators* rounds (trials 6 - 15). The presence of these peers was simulated in the task. These spectators would evaluate their decisions, but this evaluation was blurred and therefore not informative. The trial screens in this condition were similar to those in the alone block, with the addition of a feedback screen. The feedback screen contained photos of the five peers as well as their blurred evaluation and was displayed for 3000 ms (see Figure 1C: Spectator).

In the third *Feedback* condition (trials 16 – 25) participants played ten trials with a different spectator group of five peers. They learned that these spectators would evaluate their decisions with 'likes', or thumbs up for a valued decision, and that the green box would be empty if they disliked the decision. In this condition, the feedback screen was composed of photos of the spectator group and the evaluation of the participant's decision (see Figure 1C: Feedback). Lastly, the spectators went offline again, and participants played another five trials in the *Alone after feedback* condition (26 – 30) that were similar to the first five trials.

We used a mixed design with between-subjects conditions to compare two types of feedback on decisions: prosocial feedback and antisocial feedback. The TD group and the ASD group were randomly assigned to either the prosocial or antisocial feedback condition. In the prosocial feedback condition, we programmed the feedback such that spectators rewarded donations to the public goods pot with many likes, while in the antisocial feedback condition spectators gave many likes for keeping tokens to the self. As such, evaluations were dependent on the between-subjects condition as well as the participant's decision made on each respective trial. An overview of donations and associated likes in each condition is presented in Table 2.

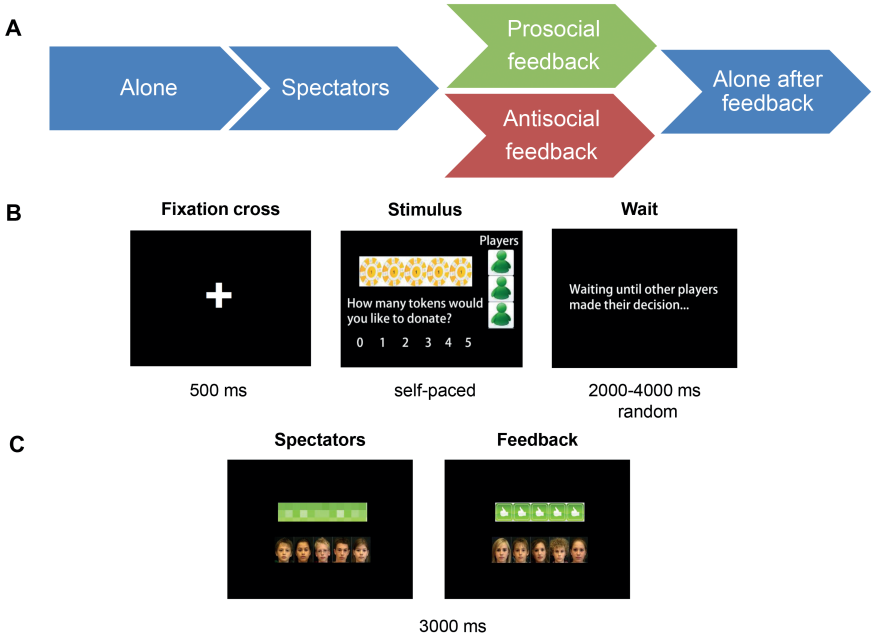

Figure 1. Illustration of the Peers Public Goods Game.

(A) Participants played four types of rounds in the PGG: *Alone*, only with group; *Spectators,* with spectators present who would evaluate their decisions, but blurred feedback; *Feedback* with spectators present who would provide either prosocial or antisocial feedback with 'likes', depending on the between-subjects condition; and *Alone after feedback*, again with group only.

(B) Illustration of screens in the alone condition. Each round, the participant makes an independent decision within their group about the allocation of five tokens between themselves and the group. The group consisted of three online age-matched peers, displayed in green to guarantee anonymity. These group members were unable to see the decisions of the participant.

(C) In the *Spectators* condition, a spectator screen followed alone trial screens. Five online spectators were able to see the decisions of the group and would evaluate these decisions, but their feedback was displayed as a blur. This condition was not of interest in the current study, but disentangles peer presence from peer feedback. In the *Feedback* condition, a feedback screen followed alone trial screens. Five different online spectators were present and provided feedback with 'likes' or thumbs up. In this case, five out of five spectators liked the participant's decision.

Table 2. *Feedback given by spectator group in the prosocial and antisocial feedback conditions.*

Number of tokens donated to the group	Prosocial feedback	Antisocial feedback
0 tokens		
1 token		
2 tokens		
3 tokens		
4 tokens		
5 tokens		

The photos of the peers in the two spectator groups were selected from a database of morphed adolescent faces. The photos in this database were non-existent identities created through overlaying pictures of two individuals (i.e., by morphing). Independent raters had previously rated these photos on several dimensions and the ten most neutral (5 males and 5 females) were selected for the current task. These photos were rated as $M(SD) = 5.02$ (0.37) on a scale of 1 (not at all neutral) – 7 (very neutral). Photos were matched on age group, which led to two different spectator groups for 11-14 year olds and 15-17 year olds.

Social interest questionnaires

Social Reward Questionnaire (SRQ-A). The Social Reward Questionnaire measures individual differences in the value of several types of social rewards (Foulkes, Viding, McCrory, & Neumann, 2014). The English version of the SRQ for adolescents includes the scales Admiration (being flattered, liked and gaining positive attention), Negative Social Potency (being cruel, callous and using others for personal gains), Passivity (giving others control over decisions), Prosocial Interactions (having kind, reciprocal relationships) and Sociability (engaging in group interactions) with a total of 20 items; no total score can be computed. The internal consistency is adequate for both groups. A bilingual Dutch-English speaker translated the items into Dutch using the forward-backwards method and we consulted the first author to make sure that the content of the translated items reflected the original SRQ items.

Resistance to Peer Influence (RPI). The Resistance to Peer Influence questionnaire assesses general resistance to peer influence, with the goal of disentangling susceptibility to peer pressure from antisocial behavior and risk-taking behavior (Steinberg & Monahan, 2007; Sumter, Bokhorst, Steinberg, & Westenberg, 2009). The scale has 10 pairs of statements and participants first have to choose which statement applies most to them, and then indicate to what extent. An example statement is "Some children think it is more important to be an individual than to adjust to the group" BUT "Other children think it is more important to adjust to the group than to be an individual". The responses are coded on a 4-point scale ranging from "Really True" or "Sort of True" as potential answers for each statement and the total RPI score is calculated as a mean of the 10 items. A high score on this questionnaire points to a high resistance to peer influence, whereas a low score implies a low resistance (Steinberg & Monahan, 2007).

Procedure

The study was conducted in an empty (class)room at school with an experimenter. All participants were tested one-on-one such that the experimenter could provide help when necessary. Experimenters were trained with video-feedback on the instructions and administration of the tasks and care was taken to take into account the needs of the ASD group, providing a structured research environment. The study was composed of three elements: (1) a task in which participants were asked to divide tokens (PGG), (2) filling out several online questionnaires, and (3) tasks with the experimenter. These tasks included the subtest Understanding Spoken Paragraphs (CELF) for all participants and the subtests of the WISC-III/WAIS-III for the TD group only, since full IQ scores were available in the ASD group.

Following the PGG instructions, including three practice trials, we administered some quiz questions to ensure that participants understood the task. Participants were informed that the computer would randomly pick one round from all PGG rounds that would be their payout for participation. In fact all participants randomly received 1, 2 or 3 euros (mean 2 euros) as compensation, as well as a small present. The payout was varied to increase credibility, because several boys from the same school class took part in the study. After all participants on a school were tested, participants were debriefed about the exact setup and goals of the study. Parents filled out a set of online questionnaires to provide background information about the sample.

Data analyses

The first aim of this study was to compare feedback sensitivity on prosocial behavior in boys with and without ASD. Effects of peer feedback in the PGG were analyzed with a Repeated Measures (RM) ANOVA, with the four PGG conditions Alone, Spectators, Feedback, and Alone after feedback as within-subjects factors. Between subjects-factors were Diagnosis (ASD and TD) and Feedback type (Prosocial feedback and Antisocial feedback). To control for possible confounding effects of estimated intelligence, we first conducted a RM ANOVA in which TIQ was included as a covariate. There were no significant effects for TIQ and therefore we excluded this variable. Second, we reran the analyses excluding ASD participants with comorbidity ($N = 18$) and TD participants with a diagnosis ($N = 2$), as well as participants who expressed doubts about belief of the task ($N = 2$) and found no changes in the results. Third, we conducted the RM ANOVA excluding ASD participants with a SRS score lower than 60 (i.e., below clinical range; $N = 12$) and found no changes in the results. Hence, we report about all participants in the Results section ($N = 144$).

Our second aim was to investigate how the severity of autism symptoms (SRS) and social interest (SRQ and RPI) relate to peer feedback sensitivity in the total sample. Peer feedback sensitivity was defined as the difference score "Feedback-Alone", i.e., the difference between donations in the feedback condition and baseline alone condition. Note that in the antisocial feedback condition, a negative difference score indicates sensitivity to peer feedback, because donations in the Feedback condition are smaller than the Alone condition. Data were analyzed with separate multiple regression models for the Prosocial feedback condition and the Antisocial feedback condition. Because of missing data in SRS and TIQ, a total of $N = 56$ participants were included in the prosocial feedback analysis and $N = 60$ participants in the antisocial feedback analysis. Predictor variables were SRS, all SRQ subscales, and RPI score, as well as TIQ to assess potential effects of intelligence.

3. Results

Descriptives ASD and TD group

Table 3 shows the mean scores on the questionnaires for the ASD and TD group separately. Mean inter-item correlations showed that the subscales were suitable for both ASD and control group, although only the RPI was below the recommended .20 for the ASD group. A *t*-test revealed that the ASD group and TD reported similar levels of Resistance to Peer Influence ($t(142) = -0.24$, $p = .810$). Separate *t*-tests revealed that differences between the groups emerged on the SRQ scales Passivity ($t(142) = -4.38$, $p < .001$) and Sociality

($t(142) = 2.19$, $p = .030$). Findings indicated that the ASD group had a higher preference for other people to make decisions for them, while they tend to engage less in group interactions relative to the TD group.

Table 3. *Mean scores on social interest questionnaires for ASD group and TD group*

Mean (*SD*)	No. items	Answer range	ASD (*N* = 75)	TD (*N* = 69)	*M* IIC ASD/TD
RPI	10	1 – 4	2.99 (0.45)	2.97 (0.52)	.14/.24
SRQ Admiration	4	1 – 7	5.00 (1.23)	5.01 (0.89)	.40/.24
Negative social potency	5	1 – 7	2.23 (0.88)	2.32 (0.77)	.32/.24
Passivity	3	1 – 7	3.24 (1.11)	2.49 (0.93)**	.40/.32
Prosocial Interactions	5	1 – 7	5.88 (0.65)	5.78 (0.73)	.29/.39
Sociality	3	1 – 7	5.10 (1.26)	5.52 (1.04)*	.42/.46

** $p < .001$, * $p < .05$

Abbreviations. RPI = Resistance to Peer Influence. SRQ = Social Reward Questionnaire. IIC = inter-item correlation. *Note.* Within the ASD sample, the Antisocial feedback group scored slightly higher ($p = .051$) on the RPI, $Mean_{PROS}(SD) = 2.89(0.48)$, $Mean_{ANTI}(SD) = 3.09(0.39)$. Within the TD sample, the Prosocial feedback group scored higher on SRQ Sociality ($p = .043$), $Mean_{PROS}(SD) = 5.77(0.78)$, $Mean_{ANTI}(SD) = 5.26(1.22)$.

Task: Peers Public Goods Game

To analyze the donations to the group in the ASD and TD group, we conducted a 2 (Diagnosis: ASD and TD) x 2 (Feedback type: prosocial feedback, antisocial feedback) x 4 (Condition: Alone, Spectator, Feedback, Alone 2) ANOVA with repeated measures of the last factor. Means for the number of tokens donated to the group in each condition for the groups are displayed in Figure 2.

Results indicated a main effect of Condition, qualified by a Feedback type x Condition interaction ($F_{GG}(3,420) = 19.39$, $p < .001$, $\eta_p^2 = .122$). There was no between-subjects effect nor interaction effect of Diagnosis, indicating that there was no behavioral difference between the ASD group and TD group. In a post-hoc comparison across Feedback types, there was no significant difference between the Alone condition and Spectators condition ($p = 1.000$). We further assessed the donation patterns for the two feedback types separately. In the Prosocial feedback condition, significantly more tokens were donated to the group when prosocial feedback was provided compared to playing Alone or with Spectators (both *p's* $< .001$). In the following Alone after feedback trials, adolescents returned to the initial Alone donation rate ($p = 1.000$).

the Antisocial feedback condition, findings revealed that fewer tokens were donated to the group when spectators provided antisocial feedback relative to playing Alone or with

Spectators (Feedback-Alone $p = .002$; Feedback-Spectator $p < .001$). Again, the donations in Alone after feedback and Alone were similar ($p = .115$).

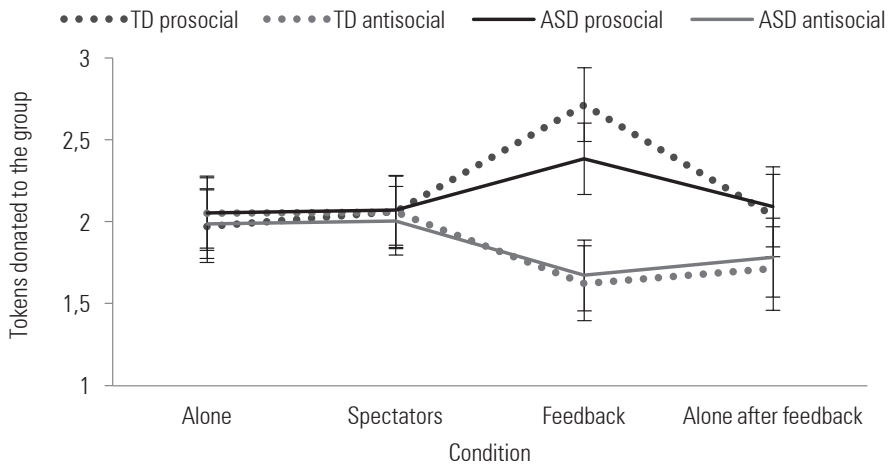

Figure 2. Mean number of tokens (out of 5 tokens) donated to the group under each PGG condition, displayed for ASD group and TD group separately for illustrative purposes. Error bars represent 1 standard error of the mean. There were neither main effects nor interaction effects of Diagnosis, indicating that adolescents with and without ASD showed no behavioral differences in the PGG. The interaction effect of Feedback type x Condition showed that participants donated more tokens in the prosocial feedback condition, and less tokens in the antisocial feedback condition.

Individual differences: Severity of autism symptoms and social interest

Regression analyses were conducted to examine how individual differences in autism symptoms and social interest play a role in sensitivity to peer feedback in the total sample. We conducted separate analyses for the Prosocial feedback condition and the Antisocial feedback condition. In each analysis we included autism symptom severity (SRS score), social reward (SRQ subscales), sensitivity to peers (RPI) and total IQ in model 1, and the interactions between SRS and these variables in model 2 to predict the difference score Feedback-Alone. In the Prosocial feedback condition, sensitivity to peer influence was not predicted by individual differences in our variables ($p = .767$). In the Antisocial feedback condition both models were significant. However, the R^2_{change} of model 2 was not significant ($p = .413$), indicating that model 1 was the best fit to the data ($F(8,51) = 2.95$; $R^2_{adj} = .212$, $p = .009$). The results of the antisocial feedback analysis are summarized in Table 4.

Table 4. *Multiple regression analysis: Sensitivity to antisocial peer feedback*

Model 1: Antisocial feedback	Correlations $N = 60$	β	*t*
SRS score	.241∼	.288*	2.10
TIQ	N/A	-.421*	-3.22
RPI	.289*	.282*	2.23
SRQ: Admiration	.264*	.355*	2.78
Negative Social Potency	-.030	-.054	-0.40
Passivity	-.046	-.004	-0.03
Sociality	-.163	-.131	-1.00
Prosocial interactions	.043	.029	0.22

** $p < .001$, * $p < .05 \sim$ p = .066.

Note. Correlations reported are partial correlations between the difference score Feedback-Alone and other variables, controlled for TIQ.

The strongest positive predictor in the model was SRQ Admiration, ($\beta = .355$, $t = 2.78$, $p = .008$), followed by SRS score ($\beta = .288$, $t = 2.10$, $p = .041$) and RPI ($\beta = .282$, $t = 2.23$, $p = .030$). This demonstrates that in the total sample, boys with more ASD symptoms, higher self-reported resistance to peers and more enjoyment of being admired for doing good were less sensitive to antisocial peer influence. On the other hand, TIQ was a negative predictor of the sensitivity to peer influence, ($\beta = -.421$, $t = -3.22$, $p = .002$) revealing that boys with a lower IQ were more sensitive to antisocial peer influence.[4]

4. Discussion

The goal of the present study was to examine peer influence on prosocial behavior in eleven-to-seventeen year-old boys with and without ASD. This was investigated with the peers public goods game (PGG) during which participants were asked to make decisions within their group in the presence or absence of peer feedback. Our key finding is that boys with and without ASD were sensitive to peer feedback on prosocial behavior. Participants donated more tokens to the group when peers endorsed prosocial behavior. Yet, prosocial behavior decreased when peers liked selfish behavior. Individual differences analyses showed that within the total sample, those with more autism symptoms and social interest were less sensitive to antisocial peer influence. Lower intelligence was associated with more sensitivity to antisocial peer influence. These outcomes will be further discussed below.

4 *Note.* If we do not include TIQ, autism symptoms are no longer a significant predictor in the regression model. This suggests that intelligence compensates for autism symptoms.

Peer feedback on prosocial behavior in TD and ASD adolescents

The current findings provide novel insights about feedback sensitivity in TD and ASD adolescents. In line with previous work, TD adolescents adjusted their prosocial behavior to social norms conveyed by peer feedback (Choukas-Bradley et al., 2015; Van Hoorn et al., 2016b). We replicated earlier results indicating that peers can provide a negative influence as well as a positive influence on prosocial behavior (Van Hoorn et al., 2016b). Although peer influence is often portrayed as vulnerability associated with an increase in health-risk behaviors, it is equally important to recognize the opportunity that lies in learning from peers during adolescence (Albert et al., 2013; Brechwald & Prinstein, 2011; Van Hoorn et al., 2016a).

Unexpectedly, we found that adolescents with ASD were also sensitive to feedback from peers, at least in the prosocial domain. Despite the social impairments that characterize ASD, the peer context seems an important environment for learning about social norms concerning prosocial behavior. These social norms entailed what the peer group considered an appropriate response in the peer context (i.e., what you are "ought" to do) (McDonald & Crandall, 2015). The disparity with previous research, which suggested diminished conformity in ASD, may result from different behavioral domains studied. Most likely, children with ASD did not conform in the context of incorrect factual information, because they tend to have a strong sense for what is factually right and have great attention to detail (Lai et al., 2014; Yafai et al., 2014). In the domain of prosocial behavior, the present findings suggest that adolescents with ASD are attuned to the peer environment, which could foster socially adaptive behavior.

In the above analysis we made a strict distinction between ASD and TD adolescents based on ASD diagnosis. More recently, autism traits have also been studied on a continuum; with individual variability in those with an ASD diagnosis and with the potential that typically developing people can also possess autism traits to a certain extent (DSM-5, APA, 2013; Yafai et al., 2014). Corroborating this perspective, the range of SRS scores indicating autism traits in the present sample shows an overlap in the ASD and TD group, although they differ significantly on a group level. Therefore, we also took a continuous approach across the total sample of adolescents, in which we examined the level of autism symptoms and the potential role of social interest in explaining individual differences in feedback sensitivity.

Individual differences in peer feedback sensitivity

In the individual differences analyses, we found that higher levels of autism symptoms and more social interest predicted less sensitivity to *antisocial* peer feedback. This specificity may be attributed to the nature of advice in the antisocial feedback condition: peer endorsement of selfish behavior. Socialization of prosocial behavior starts already early in development, when adults teach children appropriate prosocial behaviors so that they will fit in the norms of society (Padilla-Walker & Carlo, 2014). However, when children grow older, they interact with a wider range of agents including peers and social media (Rendell et al., 2011). Perhaps, those with higher levels of autism traits are less sensitive to antisocial peer feedback because being selfish is not in line with a previously learned prosocial norm from adults. Alternatively, those with more autism traits may be less sensitive to peer feedback endorsing selfish behavior because they take a more instrumental approach to prosocial behavior (Schmitz, Banerjee, Pouw, Stockmann, & Rieffe, 2015). That is, all group members including participants themselves earn more money if the group donates their tokens to the public goods pot, rather than when group members make selfish decisions. Those with higher levels of autism traits may be more focused on the overall outcome than being accepted by the online peer group.

Social interest was operationalized in the present study by the indices sensitivity/resistance to peers (RPI, Steinberg & Monahan, 2007) and social reward (SRQ, Foulkes et al., 2014). More self-reported resistance to peer influence and enjoyment of being admired for doing good were related to less sensitivity to antisocial feedback. This implicates that autism symptoms and social interest may constitute a protective factor for sensitivity to antisocial peer feedback in prosocial decision-making. On the other hand, low intelligence may represent a risk factor, as those with lower intelligence were more sensitive to antisocial feedback. This corroborates previous work reporting a positive relationship between intelligence and self-reported *resistance* to peer influence (RPI) within a large sample (Steinberg & Monahan, 2007). Potentially, adolescents with a lower IQ have more difficulties deciding what the 'right' option is in the current social dilemma, and are therefore more easily swayed in a selfish direction by peer feedback.

Taken together, these individual differences analyses revealed unique insights into the question how autism traits and social interest are related to peer feedback sensitivity. In future research, these findings need to be replicated. Social interest is a broad concept, including social attention, social reward and social maintaining (Chevallier et al., 2012). In the current study, we have focused on two specific indices relevant to adolescence and it

would be important to examine how the current results map onto other aspects of social interest.

Limitations

One limitation which should be noted is that we included only high-functioning adolescent boys with ASD. As a consequence, we cannot generalize the findings to the entire ASD population, which encompasses a broad range of social, intellectual as well as language capacities in boys and girls (Jones & Klin, 2009). Nonetheless, to our knowledge this is the first study that investigated sensitivity to peer feedback in such large samples of ASD and TD adolescents. Future research needs to extend these findings with developmental comparisons and in different domains such as risk-taking behaviors. The specificity of the source of feedback should be determined, as the current study investigated peer feedback from an unknown peer group and did not compare feedback from different sources.

In addition, the current task environment is a relatively structured social situation, and as such did not allow us to manipulate all factors that play a role in more complex social situations. At present we can only draw conclusions about a *short-term* effect of peer feedback (Van Hoorn et al., 2016b). A longitudinal design could be employed to investigate whether peer feedback continues to guide prosocial decisions in adolescents with and without ASD. Moreover, we have used the social reward questionnaire for the first time in a Dutch ASD and TD adolescent sample and this requires more thorough validation (Foulkes et al., 2014). Nonetheless, the current study can be considered a stepping-stone, which examined whether in principle this process is present in adolescents with ASD.

Conclusions and future directions

The key finding of this study was that adolescents with ASD showed sensitivity to peer feedback on prosocial behavior. More insight into the peer influence process in this population advances our knowledge of the vulnerabilities and the opportunities that may arise in the interactions with peers. Crucially, ASD adolescents seem attuned to the peer environment, which may create opportunities for social adjustment. Given the relation of autism symptoms to sensitivity to antisocial feedback, but not prosocial feedback, it may be that they operate through separate pathways. To gain more understanding of the motivations and processes underlying peer influence in ASD, future research could examine its underlying neural correlates in the developing brain.

For instance, some high-functioning individuals with ASD have been found to learn and apply social rules as a compensatory strategy to mask mentalizing problems in social situations (Hill & Frith, 2003; Jameel, Vyas, Bellesi, Cassell, & Channon, 2015). The current study did not allow us to disentangle potential compensatory strategies from actual recruitment of mentalizing abilities in the peer context. A previous neuroimaging study in TD adolescents showed involvement of the social brain network (i.e., brain regions that underlie mentalizing) during decision-making with peer feedback compared to alone (Van Hoorn, Van Dijk, Güroğlu, & Crone, 2016). A tentative hypothesis would be that ASD adolescents recruit social brain areas less if they use compensatory strategies rather than mentalizing skills during decision-making with peers present (Koster-Hale, Saxe, Dungan, & Young, 2013).

This study also has more practical implications, as it may provide a building block for interventions. To date interventions designed to increase prosocial interactions in ASD seem promising, but what works for whom is still unclear (Ledford, King, Harbin, & Zimmerman, 2016). The current findings suggest a peer component in treatment may be effective to increase prosocial behaviors in ASD. Future research should determine other individual and environmental factors that may facilitate or hinder sensitivity to peer feedback in complex real-life social situations, such that our findings can be translated into practice.