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DOI: https://doi.org/10.1002/aur.2931

Received: 30 November 2022 | Accepted: 27 March 2023

DOI: 10.1002/aur.2931

RESEARCH ARTICLE

Using simple economic games to assess social orienting and prosocial behavior in adolescents with autism spectrum disorder

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Abstract

Deficits in socio-emotional reciprocity, in prosocial behavior and in developing social relationships are diagnostic criteria of autism spectrum disorder (ASD), usually assessed by self-report or observation. Simple social experiments developed by behavioral economists allow for quantification of ASD-related social behavior. In this study, we used such experiments to compare social-economic decision-making between ASD adolescents and neurotypical controls. Precisely, we analyzed social orienting and prosocial behavior in 17 adolescents with ASD (Asperger syndrome) and 24 matched neurotypical adolescents. We used a two-condition distribution game (possibility of punishment by fellow player versus no such possibility) and an impunity game to examine social orienting (distribution game) and prosocial behavior (both games). Participants with ASD exhibited less social orienting in the distribution game ($p = 0.03$, $d = -0.61$). In addition, there was a trend for ASD participants to behave in a more prosocial way than neurotypical participants in the impunity game ($p = 0.08$, $d = 0.60$), which was not the case in the no-punishment condition of the distribution game ($p = 0.35$, $r = 0.17$). These results demonstrate the potential of simple economic games to capture reduced social orienting in ASD. The unexpected finding of more prosocial behavior in adolescents with autism spectrum disorder than in neurotypical controls adds to the complexity of previously published results. We recommend meta-analytic efforts to determine average effect sizes across studies and elucidate the conditions for prosocial behavior in ASD to occur.

Lay Summary

These results show that simple economic games can be good for measuring reduced social orienting in autism spectrum disorder. Our study also shows that under some conditions and on average, autistic people are more altruistic than people without autism. These findings matter as they could help clinicians improve their diagnostic methods. They could also help identify resiliency factors like altruism in autism spectrum disorder.

KEYWORDS
autism spectrum disorder, distribution game, impunity game, prosocial behavior, social-economic decision-making

INTRODUCTION

Social Orienting and Prosocial Behavior in Autistic versus Neurotypical Male Adolescents.

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by core symptoms of social interaction impairments, communication deficits, and repetitive, stereotypic, or restricted behavior (American

Psychiatric Association, 2013). Symptoms must be present in the early developmental period, but may not be fully developed until social demands exceed the individual's limited capacities, and may be masked by compensatory strategies later in life. Researchers have attributed these core symptoms to various factors, including cognitive deficits (deficits in perspective-taking/theory of mind), greater sensitivity to sensory input, and social motivational deficits (social orienting, seeking, and maintaining; Chevallier et al., 2012; Lord et al., 2020). More distally, these alterations have been suggested to reflect polygenic variation, epigenetic alteration, pre- and perinatal stress factors (e.g., preterm birth, neonatal hypoxia, short interpregnancy interval, gestational diabetes mellitus), brain volume overgrowth, and environmental toxin exposure (e.g., pesticides, air pollution; Lord et al., 2020). The DSM-5 introduced ASD as an umbrella diagnosis for previously distinct disorders on the spectrum, namely: Asperger syndrome, autistic disorder, pervasive developmental disorder not otherwise specified, and childhood disintegrative disorder (American Psychiatric Association, 2013).

This study compared adolescents on the autism spectrum with neurotypical peers regarding their responsiveness to social-environmental cues and prosocial behavior in a social-economic decision-making paradigm. One should note that prosocial behavior is a diverse phenomenon associated with various different definitions, which makes it important for empirical research to clarify how it defines and operationalizes prosocial behavior (Pfattheicher et al., 2022). This study conceptualized prosocial behavior from an economic-consequentialist perspective, operationalizing it as resource-costly behavior that benefits other individuals as recipients of donated personal resources (e.g., as Fehr & Fischbacher, 2003).

Previous evidence suggests that ASD features altered attentional responsiveness to social stimuli like human faces, also referred to as social orienting (Chevallier et al., 2012). A meta-analysis found consistent evidence for reduced social orienting, but not for reduced social seeking (the overt behavioral tendency toward social interaction) in ASD relative to neurotypical individuals (Hedger et al., 2020). That is, ASD patients may focus less on social stimuli than neurotypical individuals, but they are still willing to expend similar behavioral effort to obtain them. The magnitude of the difference in social orienting also appears to depend on contextual factors. Thus, although a person with ASD may have an attentional bias toward stimuli of interest that are nonsocial in nature, this bias need not necessarily reflect a motivational deficit to expend effort in social contexts. A reduction in social orienting has also been observed in neuroeconomics paradigms. For example, high-functioning adults with ASD did not donate significantly more to charity in the presence of an observer compared to when alone, whereas neurotypical controls donated significantly more with an observer present, suggesting less social orienting in the ASD group (Izuma et al., 2011).

Apart from the tendency to adjust one's donation behavior to social cues (e.g., observer presence), one could also examine differences in average donations (i.e., general prosocial behavior) between ASD- and non-ASD individuals. A few studies have researched the association between ASD and prosocial behavior and found an equivocal picture. One study found that individuals with more autistic traits made fewer prosocial choices (Jameel et al., 2014). Other studies found no significant associations between ASD or autistic traits and prosocial behavior in terms of donating or helping (Bethlehem et al., 2017; Izuma et al., 2011; Sally & Hill, 2006). For example, Izuma and colleagues (Izuma et al., 2011) found only a nonsignificant trend toward less donations in high-functioning ASD, compared with neurotypical participants. Bethlehem et al. (2017) also found no significant association between ASD symptoms and altruistic helping, despite the finding that empathy, which was negatively associated with ASD symptoms, positively predicted altruistic helping.

In contrast, a recent study that examined prosocial behavior (donating self-relevant items) and hypocrisy (the difference between one's reported hypothetical donation preferences and actual donations when able to donate the actual items) in children found a different result (Peterson & Wellman, 2022). There was a trend toward more prosocial behavior in the form of self-relevant items given away to an unknown peer, and a significant effect of less hypocrisy (less discrepancy between costly and uncostly prosocial behaviors) in ASD, relative to non-ASD children. Another study found that preschool-aged children with ASD behaved more altruistically than neurotypical controls by helping an experimenter and sharing distributable resources relatively more selflessly, especially when the recipient of the resources was not present (Paulus & Rosal-Grifoll, 2017). As these studies involved only children, though, it is unclear whether they generalize to adolescent and adult populations. Thus, one of the current study's purposes was to add to the literature comparing prosocial behavior between ASD and non-ASD adolescents.

In sum, the existing literature suggests that ASD is associated with less social orienting; that is, less responsiveness to social cues like the presence of a peer who might react to the individual's decision (e.g., by punishing unfair resource allocation behavior). Moreover, the relationship between ASD and prosocial behavior appears to be unclear and deserves further study. To further elucidate the relationship between ASD and social-economic decision-making outcomes reflecting social orienting and prosocial behavior, we aimed to investigate these variables in adolescents with ASD relative to neurotypical adolescents. We hypothesized that in a social-economic decision-making setting, the ASD group would be less responsive than the neurotypical group to social-

environmental cues associated with punishment (exhibiting a smaller difference between money allocations to others in a punishment-free and a potential punishment condition in a distribution game), indicating less social orienting. We also explored the relationship between ASD and prosocial behavior (the tendency to share money with a peer, rather than choosing a self-serving alternative in an impunity game). Due to the mixed results in the literature, we did not specify any directional hypothesis here. We also included secondary variables of interest to explore whether these variables correlate with the key ASD or social-economic decision-making variables; namely empathy, perceived social support, and self-reported depression symptoms (Alvarez-Fernandez et al., 2017; Baron-Cohen & Wheelwright, 2004; Stewart et al., 2006).

METHOD

Participants

The sample included 41 male adolescents, of which 24 were neurotypical controls (NC group; age $M = 17.08$, $SD = 2.72$) and 17 qualified for Asperger syndrome diagnoses (ASD group; age $M = 16.90$ years, $SD = 2.46$). The two groups were matched on control variables such as age, education level, and history of smoking, alcohol, or drug use (all $p > 0.11$). There was comorbidity in six of the 17 ASD participants (35% prevalence), with four instances of one, one patient with three, and one patient with four additional diagnoses. Anxiety disorders were most common (29% prevalence; F40.00, 2x F40.1, F40.2, F42.8), followed by mood (18% prevalence; F32.2, F32.x, F33.0) and hyperkinetic disorders (18% prevalence; 2x F90.0, F90.x). This observed comorbidity was similar to comorbidity rates described in the literature (Lord et al., 2020). The majority of the ASD group was unmedicated, with six participants (35%) maintaining psychotropic medication during the study (3x methylphenidate, 2x venlafaxine, 1x mirtazapine). Exclusion criteria were psychotic disorder, substance dependence disorder, severe eating disorder, acute major depressive or manic episode, IQ < 80, or an inability to understand study requirements or severe attention deficit.

Materials

Diagnostic interviews

The Mini-International Neuropsychiatric Interview for Children and Adolescents is a structured clinical diagnostic interview developed to examine and diagnose psychiatric disorders in children and adolescents consistent with the DSM-IV and ICD-10 (Sheehan et al., 2010). In keeping with the adult version of the interview, it examines a variety of DSM-IV and ICD-10-based diagnoses such as affective disorders, substance use and dependence disorders, psychotic disorders, eating disorders, and relevant child and adolescent psychiatric diagnoses like separation anxiety, attention deficit and hyperactivity disorder, conduct disorder, and developmental disorders. The interview is a reliable and valid instrument that exhibited convergent validity with the Schedule for Affective Disorders and Schizophrenia for School Aged Children—Present and Lifetime Version (Duncan et al., 2018; Sheehan et al., 2010).

Questionnaires

Beck depression inventory

The Beck depression inventory (BDI) is a very widely used measure of depression symptomatology (Beck et al., 1961; Hautzinger et al., 1994). It comprises 21 self-report items with a possible score range of 0–63 and exhibited strong reliability and validity in many previous studies, including research in child and adolescent populations (Stockings et al., 2015). It exhibited acceptable internal consistency in the current study (Cronbach's $\alpha = 0.82$).

Autism spectrum symptoms

The adolescent version of the Autism-Spectrum Quotient assessed autism spectrum symptoms (Baron-Cohen et al., 2006). The Autism-Spectrum Quotient contains 50 items and is a widely used measure with previously demonstrated acceptable reliability and validity (Armstrong & Iarocci, 2013; Bethlehem et al., 2017). It exhibited strong internal consistency in this study (Cronbach's $\alpha = 0.91$).

Empathy

The Empathy Quotient is a 60-item self-report questionnaire that measures empathy as a key correlate of autism spectrum disorders (Baron-Cohen & Wheelwright, 2004). The questionnaire includes 40 items for the measurement of empathy and 20 filler items to distract the participant from the measurement of empathy. It has shown strong 12-month test–retest reliability ($r = 0.97$) and internal consistency (Cronbach's $\alpha = 0.92$; present study: Cronbach's $\alpha = 0.90$). The Empathy Quotient validation research found a negative correlation with autism symptoms and significantly lower scores in adults with ASD or high-functioning autism than in NC participants, justifying its use as a correlate (Baron-Cohen & Wheelwright, 2004). The Empathy Quotient has been widely used in comparable studies (Bethlehem et al., 2017; Izuma et al., 2011).

Social support

To measure generally perceived social support, we used the 14-item version of the "F-SozU" social support questionnaire, which featured strong internal consistency

(Cronbach's $\alpha = 0.94$; present study: Cronbach's $\alpha = 0.92$) and test–retest reliability in previous research ($r = 0.96$; Fydrich et al., 2009).

Ethical considerations

The study took place at the University Hospital of Child and Adolescent Psychiatry and Psychotherapy Bern and was approved by the cantonal ethical committee Bern (KEK-Gesuch Nr. 260/09). All participants provided written informed consent. For all underage participants, the legal caregivers also provided written consent.

Procedure

The study was conducted in collaboration with University Hospital of Child and Adolescent Psychiatry and Psychotherapy Bern. The hospital informed ASD patients who fulfilled the study criteria (ascertained during the hospital's standard diagnostic procedures) and their caregivers about the possible study participation. The hospital then referred any interested ASD participants to the study team; whereas the study team recruited NC participants using convenience sampling methods. Upon admission to the study, a trained clinician conducted the Mini-International Neuropsychiatric Interview for Children and Adolescents with each participant. To participate in the entire study, ASD participants needed to qualify for an Asperger syndrome diagnosis (DSM-IV TR 299.80/ICD-10F84.5) and NC participants needed to not qualify for any diagnosis in this interview. Participants then completed two social-economic decision-making experiments. In the first, they played 10 rounds of a distribution game with two conditions (punishment threat vs. no punishment possible, five rounds per condition; Gianotti et al., 2018). In each round, participants could split 100 points between themselves and an unknown peer, who supposedly changed every round. The conditions were presented in a randomized order and included the possibility to be punished for one's decision (e.g., for a potentially unfair split) versus definitive absence of punishment. In the punishment threat condition, participants were informed that both players would receive an extra 25 points after the initial allocation was made, which the recipient could use to punish the participant by deducting the five-fold magnitude of the invested amount (e.g., 20 points invested in punishment would deduct 100 points from the participant).

In the second social-economic decision-making experiment, participants played 24 rounds of an impunity game (Bolton & Zwick, 1995). In this game, participants could choose from two proposed options (more vs. less prosocial) for allocating money to themselves and an unknown peer player who was constant across trials and had no option to punish the participant for their decisions. After the impunity game, participants finished the study by completing the remaining questionnaires.

The order of the decision-making games was randomized. The experimenter delivered a standardized set of instructions and ensured that participants understood the decision-making game mechanisms and rules by asking two control questions before each game. The experimenter clarified the rules again if the participants had any apparent doubts or difficulty understanding the game.

Statistical analyses

To test the main hypothesis, we analyzed a difference score of investment in the punishment condition minus investment in the no-punishment condition in the distribution game. We performed an independent-samples *t*-test to compare ASD with NC participants.

For control and exploratory purposes, we compared the ASD and NC groups on the secondary variables of the study (autism spectrum quotient, empathy quotient, BDI, social support, age in years, years in school) with independent samples *t*-tests. We also computed Pearson correlations for all continuous (main outcome & secondary) variables.

To explore the association between ASD and prosocial behavior, we conducted two tests. We used an independent-samples *t*-test on the impunity game data. Because the average points allocated to oneself and the average points allocated to player 2 across the 24 rounds of the game were inversely correlated ($r = -0.50$), we created a combined allocation variable indicating the tendency to allocate points to player 2, rather than to oneself. For this combined allocation variable, we standardized average points allocated to oneself and average points allocated to player 2; and summed the standardized allocation to player 2 with the negatively weighted standardized allocation to oneself (meaning that higher scores denote more prosocial behavior). As the no-punishment condition of the distribution game also permitted a group comparison of prosocial behavior, we used another independent-samples test to test the ASD-NC difference this condition, too. To check *t*-test assumptions of normality and homogeneity of variance, we inspected histograms and conducted Levene's test. In the no-punishment condition of the distribution game, the normality assumption was violated, so we used a nonparametric alternative (Mann–Whitney *U* test). As the direction of the main hypothesis was clearly specified, we conducted a one-tailed test here; whereas all other tests remained two-tailed. We computed Cohen's *d* and its nonparametric alternative *r* as measures of effect size and interpreted them according to Cohen's interpretative guidelines (Cohen, 1992). The significance level was $\alpha = 0.05$.

RESULTS

Table 1 presents descriptive statistics for and correlations among the main variables. Table 2 presents the results of the control comparisons between the ASD and the NC groups.

Social orienting

The distribution game money allocation difference was positive in both groups, indicating greater average allocations to player 2 in the punishment ($M = 37.76$) than in the no-punishment condition ($M = 10.24$) in the whole sample, $t(40) = 10.72$, $p < 0.001$, $d = 1.67$ (Figure 1). The independent-samples t-test of distribution game money allocation differences found a significant difference between the ASD and the NC group, $t(30.28) = -1.89$, $p = 0.03$, $d = -0.61$. Precisely, the punishment-no punishment difference in allocations to player 2 was smaller in the ASD ($M = 21.76$) than in the NC group ($M = 31.58$). The d of -0.61 indicated a medium effect size (Cohen, 1992). Separate group comparisons for the punishment and no-punishment condition are found in Figure 2a,b, respectively. The comparison of the punishment condition only showed no significant difference between the groups, $t(38.11) = -0.89$, $p = 0.38$, $d = -0.28$.

Prosocial behavior

The independent-samples t-test of impunity game combined allocation scores showed no statistically significant difference between the ASD ($M = 0.31$) and the NC group, $M = -0.22$, $t(26.05) = 1.85$, $p = 0.08$, $d = 0.60$; see Figure 3. However, the d of 0.6 corresponded to a medium effect size (Cohen, 1992), indicating a trend toward more money allocation to the other player and less to oneself by ASD than by NC participants. In the no-punishment condition of the distribution game, the Mann–Whitney U test showed no significant difference ($W = 239.50$, $p = 0.35$, $r = 0.17$, $d = 0.49$; see Figure 2b).

DISCUSSION

The present study examined social orienting and prosocial behavior in a behavioral economic decision-making paradigm in ASD relative to NC adolescents. Supporting the main hypothesis, ASD adolescents made decisions

TABLE 1 Secondary comparisons between ASD and NC groups

	M_{ASD}	SD_{ASD}	M_{NC}	SD_{NC}	t	df	p	d
Distribution game allocation difference	21.76	17.62	31.58	14.55	−1.89	30.28	0.03	−0.61
Impunity game combined allocation	0.31	1.02	−0.22	0.68	1.85	26.05	0.08	0.60
Autism spectrum quotient	24.65	9.31	13.29	4.47	4.66	21.25	<0.001	1.56
Empathy quotient	34.47	15.86	40.67	10.50	−1.41	25.75	0.17	−0.46
Beck depression inventory	4.12	4.87	2.42	2.41	1.33	21.59	0.20	0.44
Social support	3.87	0.79	4.39	0.55	−2.35	26.71	0.03	−0.77
Age in years	16.90	2.46	17.08	2.72	−0.22	36.62	0.82	−0.07
Years in school	9.18	2.01	10.46	2.26	−1.92	36.70	0.06	−0.60

Note: $N_{ASD} = 17$, $N_{NC} = 24$.
Abbreviations: ASD, autism spectrum disorder; NC, neurotypical controls.

TABLE 2 Correlations among key variables

	M	SD	1.	2.	3.	4.	5.	6.	7.
1. Punishment-no punishment difference (distribution game)	27.51	16.43	N/A						
2. Combined allocation (impunity game)	0.00	0.87	−0.37*	N/A					
3. Autism spectrum quotient	18.00	8.84	−0.19	0.14	0.91				
4. Empathy quotient	38.10	13.17	0.10	0.06	−0.59***	0.90			
5. Beck depression inventory	3.12	3.68	−0.27	0.25	0.34*	−0.04	0.82		
6. Social support	4.17	0.70	0.20	0.07	−0.30	0.58***	−0.15	0.92	
7. Age in years	17.01	2.58	−0.20	0.21	−0.02	0.22	0.30	0.12	N/A
8. Years in school	9.93	2.21	−0.08	0.18	−0.31	0.35*	0.18	0.10	0.69***

Note: $N = 41$. Where applicable, the diagonal presents Cronbach's α.

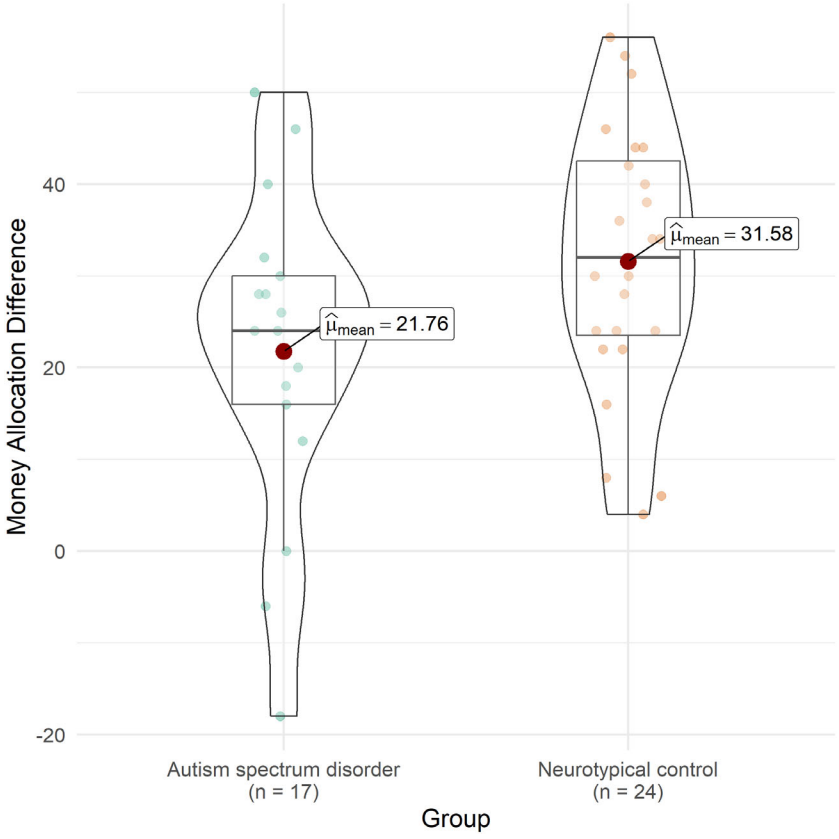

FIGURE 1 Violin plot of distribution game punishment-no punishment difference in money allocation by group. Distribution game punishment minus no-punishment condition money allocation differences differed significantly by group ($p = 0.03$, $d = -0.61$), indicating less discrepant decision-making between conditions in the autism spectrum disorder than the neurotypical control group

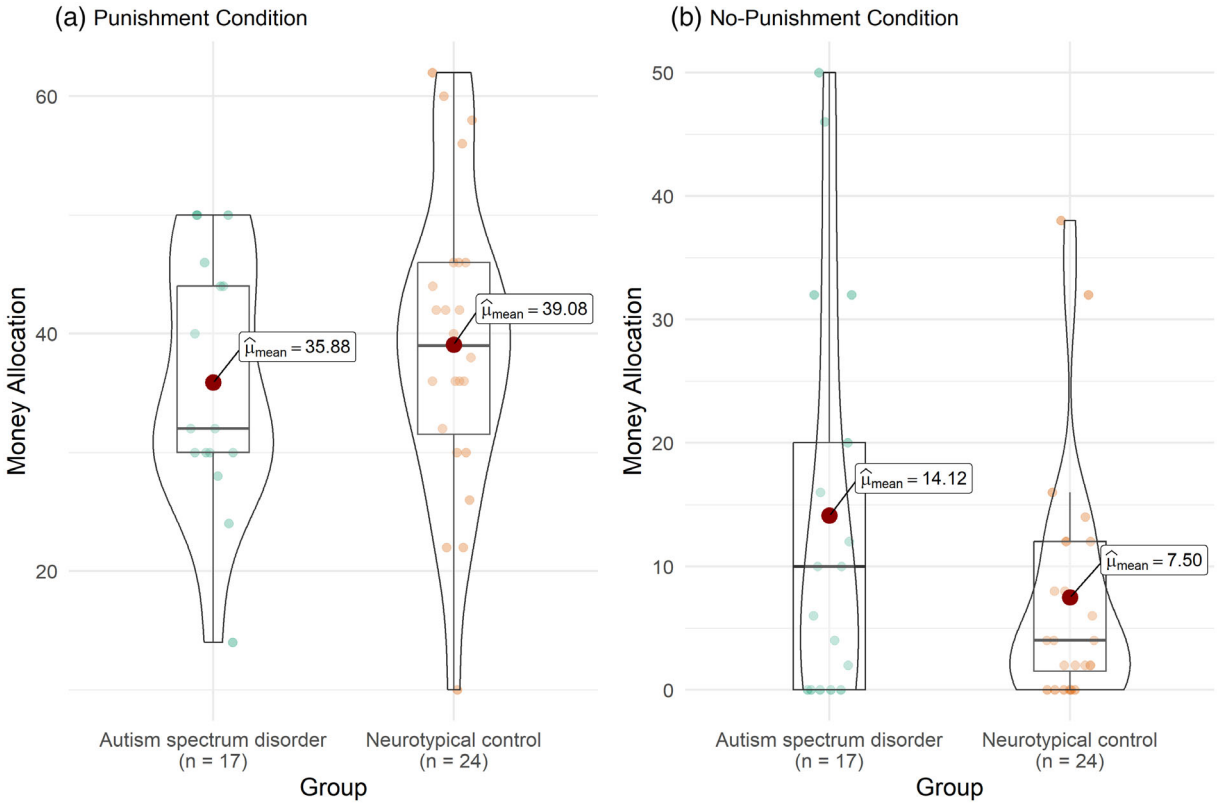

FIGURE 2 Violin plots of distribution game money allocation by group and condition. (a) Punishment condition money allocation did not differ significantly by group ($p = 0.38$, $d = -0.28$). (b) No-punishment condition money allocation did not differ significantly by group ($p = 0.35$, $r = 0.17$, $d = 0.49$), indicating no significant difference in prosocial behavior between the autism spectrum disorder and the neurotypical control group

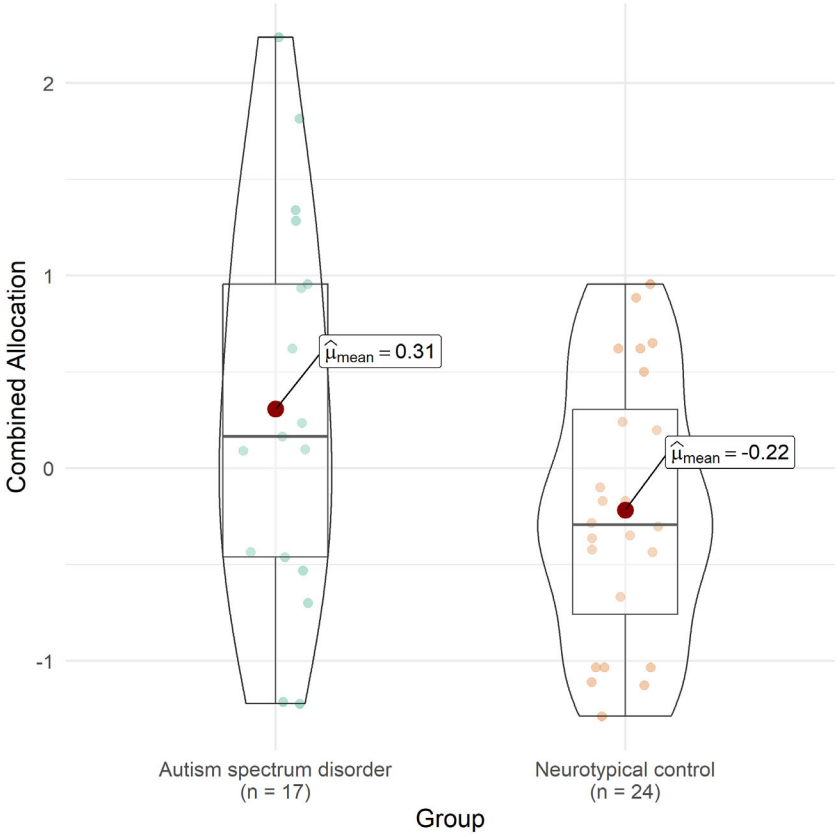

FIGURE 3 Violin plot of impunity game combined allocation by group. Impunity game combined money allocation did not differ significantly by group despite a medium effect size ($p = 0.08$, $d = 0.60$); indicating a nonsignificant trend toward more prosocial behavior in the autism spectrum disorder than in the neurotypical control group

consistent with less social orienting than their neurotypical peers. There was a trend of medium effect size toward more prosocial behavior in the impunity game for ASD, relative to NC adolescents, but no such difference was observed in the no-punishment condition of the distribution game. The direct observation of ASD-relevant behaviors in simple economic games is a key strength of this study, which could be easily extended to study the neuroimaging correlates of or psychoactive substance effects on social orienting and prosocial behavior.

The results supported the main hypothesis and also showed that a simple economic game has the potential to measure reduced social orienting behavior in ASD. They are consistent with prior findings; for example of a study with high-functioning adults with ASD whose donation decisions were not significantly affected by the presence (versus absence) of an observer (Izuma et al., 2011). In contrast, neurotypical adults, much akin to the present study, decided to donate significantly more with (versus without) an observer present. A study of children with and without ASD found a similar result, where the behavioral difference between ASD and neurotypical children was greater when the donation recipient was absent (Paulus & Rosal-Grifoll, 2017). Research by Peterson and Wellman (2022) also demonstrated less social orienting in children with ASD as they exhibited less hypocrisy; that is, less discrepancy between their reported donation preferences (where high donation preferences are socially desirable and uncostly) and their actual donations (where donating more is socially desirable, but also more costly). Tei and colleagues (Tei et al., 2019) found more consistent social discounting behavior in ASD than in neurotypical adults, being less influenced by social distance to the recipient. Finally, Li and colleagues (Li et al., 2014) found that high-functioning ASD children, relative to neurotypical children, exhibited less large discrepancies in cooperative behavior between playing a prisoner's dilemma game with a supposedly nice versus a supposedly naughty peer.

In line with a recent meta-analysis (Hedger et al., 2020), these findings could be interpreted as reflecting a deficit in social orienting, meaning that individuals with ASD attend and thereby respond less to social stimuli. This view would be consistent with the social motivation theory of autism (Chevallier et al., 2012), which posits that ASD could be seen as an extreme form of diminished social motivation and is rooted in aberrant processing of social rewards and rejection avoidance. Subsequent research linked these proposed social motivation deficits in ASD with altered mesolimbic dopamine function (Dichter & Rodriguez-Romaguera, 2022) and reduced extrastriatal D2/3 receptor availability (Murayama et al., 2022). Social motivation theory also posits that people with ASD may often have normal, if not enhanced, empathic abilities and social sensitivity; but this may not translate to prosocial behavior due to the aforementioned rejection avoidance motives preventing people with ASD from engaging in social situations.

Indeed, adults with ASD have been shown to avoid social situations due to the stress experienced in such situations (McQuaid et al., 2022). The present findings support the idea of normal or enhanced prosocial tendencies in ASD, as ASD adolescents exhibited more prosocial behavior than controls. Future research could examine whether enhanced prosocial behavior in people with ASD can be masked by perceived stress, social anxiety, or rejection avoidance motives in real-world social situations, which might explain discrepant research findings regarding ASD and prosocial behavior.

Instead of using a deficit framework like social motivation theory, though, one could also interpret the present results as consistent with interactional frameworks such as the double empathy problem view (Milton, 2012). This view holds that autistic individuals are different from the normative nonautistic majority in their social interactions and are less sensitive to social cues that neurotypical people react strongly to (e.g., punishment-related cues), but are not necessarily deficient in prosociality. The present finding of heightened prosociality that is independent of the threat of social costs shows that autistic individuals might indeed simply interact differently from neurotypical individuals, without deficits in prosocial behavior. Similarly, one could interpret the finding of a smaller difference between punishment and no-punishment conditions in ASD adolescents as relatively more consistent (and thereby fair) behavior for a non-deficit-based explanation of ASD-related behavior.

In this study, ASD adolescents behaved in a more prosocial and less self-serving way than their neurotypical peers in an impunity game. This finding is interesting given the mixed results in previous studies. For example, it is consistent with other studies employing neuroeconomics paradigms like the ultimatum game (Ikuse et al., 2018), dictator game (Klapwijk et al., 2017), or other resource allocation games (Tei et al., 2019), which found more prosocial behavior in ASD than in non-ASD participants of child, adolescent, and adult age (Paulus & Rosal-Grifoll, 2017). Moreover, research found that high-functioning ASD children judged the immoral behavior of an unknown peer more strictly (Li et al., 2014) and endorsed punishment of immoral behavior in a prisoner's dilemma game more often than NC (Li et al., 2018); which is in line with Baron-Cohen's (2005) conclusion that despite being rather self-focused, people scoring high on the autism spectrum have strong moral values, sense of justice, and think deeply about how to do good.

In contrast, some research found reduced prosocial behavior in ASD. Ringshaw and colleagues (Ringshaw et al., 2022) found that boys with ASD between 6 and 12 years of age were less prosocial in a moral decision-making task than matched neurotypical boys. Moreover, Lin and colleagues (Lin et al., 2012) found high-functioning ASD adults to donate significantly less to non-autism-related social charities than neurotypical adults. They also found a general trend toward less and lower general donations. However, there were no significant differences in donations to environment-, animal-, and autism-related charity donations (where the trend was reversed in favor of more donations by ASD participants). Jameel et al. (2014) found participants with relatively pronounced ASD symptoms to behave in a less prosocial way in a laboratory paradigm. Another study found that high-functioning ASD children were less cooperative than typically developing children when playing a prisoner's dilemma game with a supposedly prosocial versus a supposedly antisocial peer (Li et al., 2014), and other research found children with ASD to score lower on instrumental, informative, and empathic helping than typically developing children (Greenslade & Coggins, 2022).

However, the majority of the literature found no association between ASD or autism symptoms and prosocial behavior, indicating that ASD does not impact one's general propensity toward altruistic values or behavior (Bethlehem et al., 2017; Chiu et al., 2008; Downs & Smith, 2004; Hill et al., 2004; Izuma et al., 2011; Sally & Hill, 2006; Townsend et al., 2021). These mixed results might be partly due to the reliance on diverse paradigms to measure prosocial behavior. For example, Wang et al. (2022) found that ASD and non-ASD children did not differ on parent-rated prosocial behavior, but did behave less altruistically in a dictator game. The study's use of a behavioral game can be regarded as a methodological strength, since prosocial behavior involving real resources was directly measured and did not just involve indirect reports. As the results showed that direct and indirect measures of prosocial behavior can yield divergent results, the present study's use of a direct (i.e., behavioral) measure represents a key strength. Given the divergent results in the literature, a meta-analysis could provide a useful overview over the average association between ASD and prosocial behavior, as well as the effects of various moderators (e.g., measurement paradigm, sample age, cognitive ability, control group characteristics).

The secondary group comparisons between ASD and NC participants on empathy, depression symptoms, and social support (as well as their correlation equivalents between ASD symptoms and said outcomes) provided additional information. Empathy was not significantly different between the ASD and the NC group, featuring only a weak effect size. This contradicts the predominant association between ASD and empathy in the literature. However, autism spectrum quotient scores were significantly negatively correlated with empathy quotient scores, replicating the association between general empathy and ASD symptoms (e.g., Bethlehem et al., 2017).

Consistent with previous findings (Alvarez-Fernandez et al., 2017), ASD participants reported significantly less perceived social support than NC participants. The correlation between the autism spectrum quotient and social

support was moderately negative, but did not attain statistical significance. The difference might have been more pronounced for the dichotomous diagnostic group comparison because a mental disorder diagnosis can create social stigma and exacerbate existing negative social dynamics, leading to diminished social support. However, it might also be that individuals with low social support are more likely to get diagnosed in general. As low social support has been associated with lower subjective wellbeing (Bailey et al., 2020), it might be more likely for someone on the extreme end of the autism spectrum with low social support and relatively low subjective well-being to seek treatment for their mental condition and be diagnosed with ASD in the process, compared to someone with comparable ASD symptoms, but better subjective well-being thanks to high social support.

There was a significant positive correlation between autism spectrum quotient and self-reported depression symptoms on the BDI. Although the ASD-NC group difference was not statistically significant, it amounted to a small, nearly moderate, effect size in the same direction (more depression symptoms in participants with ASD). This is consistent with previous literature identifying depression as a frequent comorbidity in ASD (Stewart et al., 2006). However, depression symptoms were uncorrelated with prosocial behavior and social orienting in the economic games and thus cannot explain the ASD-NC differences on these outcomes. Comparing this finding to the extant literature is difficult because most studies reported group comparisons, but no correlations between the BDI and social-economic decision-making outcomes. For example, in one study, suicidal depression patients with higher BDI scores engaged in more reciprocity behavior in a modified Trust Game than nonsuicidal depression patients with lower BDI scores (Caceda et al., 2014). In another study, depression patients with higher BDI scores offered more money (i.e., engaged in more prosocial behavior) in the ultimatum game than healthy controls with lower BDI scores (Destoop et al., 2012). Thus, the absence of association between BDI scores and social-economic decision-making in the current study is somewhat inconsistent with previous results, albeit not perfectly commensurable. This may be due to differences in statistical comparisons (continuous versus group-based associations) and differences in the range of depressive symptoms (minimal to severe in the previous studies opposed to minimal to mild in the present study).

In contrast to the association between ASD and social-economic decision-making outcomes, depression symptoms might indeed explain the lower social support reported by ASD than by NC participants, as previous research has found increases in depression symptoms to predict decreases in social support (Ren et al., 2018). Previous work also showed that psychotherapy for depression improved perceptions of social support (Park et al., 2014). Importantly, perceived social support did not correlate with social orienting and prosocial behavior in the present study, excluding the possibility of social support explaining the ASD-NC differences in social-economic decision-making.

This study was limited by a few issues. First, it featured a relatively small sample size. Given the clinical context, this is not unusual, but this makes it imperative to replicate the results in a larger sample (e.g., with a multi-center study). The second limitation also relates to the size of the study: there were no female participants and thus, sex differences could not be analyzed. With a large-scale review finding an overall pooled male: female ratio of over 4:1 (Loomes et al., 2017), a larger study would have been needed to examine sex effects appropriately. A third and minor limitation concerns the use of (DSM-IV-based) Asperger syndrome diagnoses instead of (DSM-5-based) ASD diagnoses. This is due to the study methodology having been designed before the introduction of the DSM-5. As Asperger syndrome was subsumed by ASD in the DSM-5, our participants would qualify for an ASD diagnosis according to the DSM-5, but it is unclear whether the current results generalize to different subtypes of ASD; that is, to patients who would have previously been diagnosed with autistic disorder, pervasive developmental disorder, and childhood disintegrative disorder.

In conclusion, ASD adolescents exhibited significantly less social orienting and tended to behave in a more prosocial fashion in an impunity game than neurotypical participants in this study. This study encourages future research using simple economic games to elucidate the neurobiological underpinnings of reduced social orienting. ASD participants' trend toward more prosocial behavior is scientifically and clinically of great importance and may represent a resilience factor in ASD. Given the inconsistent results on prosocial behavior in ASD, future studies should meta-analyze the relationship between ASD and prosocial behavior to determine factors and conditions associated with prosocial behaviors and resilience in ASD.

ACKNOWLEDGMENTS

This study was supported by the University of Bern and the University of Fribourg. The authors thank Carol Nievergelt and Matthias Huber, both University Hospital of Child and Adolescent Psychiatry and Psychotherapy Bern, Switzerland, for their expertise regarding informing, assessing and testing adolescents with autism spectrum disorder. Open access funding provided by Universite de Fribourg.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICS STATEMENT

The study was prospectively reviewed and approved by the responsible cantonal ethical committee (KEK Bern, protocol number 072/13) and performed in accordance with the ethical standards of the Declaration of Helsinki. All participants or their legal caregivers (in the case of underage participants) provided written informed consent.

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How to cite this article: Hase, A., Haynes, M., & Hasler, G. (2023). Using simple economic games to assess social orienting and prosocial behavior in adolescents with autism spectrum disorder. *Autism Research*, *16*(6), 1199–1209. https://doi.org/10.1002/aur.2931