Original Article

autism

Autism
1–15

DOI: 10.1177/13623613251323493
journals.sagepub.com/home/aut
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Understanding decision-making in autistic children and adolescents: Insights from deliberative processes and behavioral economic paradigms

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Abstract

Prior research has shown conflicting findings on decision-making differences between autistic and non-autistic individuals. To address this issue, we applied the Ultimatum and Dictator Games to examine explicit measures (probability of endorsing monetary offers) and implicit measures (response times) associated with decision-making behaviors. By analyzing response times, we aimed to determine whether decisions were intuitive (rapid) or deliberative (slower) reasoning processes. In addition, we administered an executive functions questionnaire to explore how cognitive skills correlate with implicit and explicit decision-making behaviors. The study included 24 autistic and 24 non-autistic children and adolescents aged 8–18 years. Results showed that autistic participants were less likely to propose selfish offers in the Dictator Game than their non-autistic peers. Among autistic participants, this lower tendency to propose selfish offers correlated with better executive function skills. Regarding response times, autistic participants exhibited slower responses than non-autistic participants when accepting and proposing selfish offers in both games. These findings reveal differences in selfish offer tendencies and deliberative reasoning among participants, suggesting that slower decision-making in autistic participants reflects a focus on fairness and sociomoral reasoning. Future research can explore how this reasoning style influences social interactions in various scenarios.

Lay Abstract

Autistic kids and teens often have unique ways of communicating and socializing with others. Making decisions is important in how we behave daily and how we socialize. To study if autistic participants tend to make more cooperative or selfish choices, we used two games where participants had to share money between themselves and another player. Previous results were not consistent and that is why general assumptions could not be established. Also, previous results focused on the final decisions and did not consider the process that leads to making decisions. To fill the gap in what we know, this study dug deeper by evaluating how quickly or slowly participants made decisions and explored executive functions needed for daily decisions. The study found that autistic participants, with better executive functions, made less selfish offers (where they could keep more money than their peers) than non-autistic participants. Also, autistic participants took more time to decide than non-autistic participants, only when they could earn more money than the other player. Interestingly, these results are consistent with studies indicating that autistic children distribute resources without a primary focus on personal gains. These findings reshape how we view social exchanges and recognize that slow, deliberate thinking can lead to less selfish decisions in autistic children and adolescents. Future research could explore how this reasoning style influences social interactions in varied contexts.

Keywords

cooperation, decision-making, dictator game, executive function, fairness, prosocial behavior, selfish, social functioning, ultimatum game

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Introduction

Effective decision-making involves choosing the most suitable option from various alternatives to maximize the cost–benefit outcome (Sanfey, 2007). In recent years, this topic has gained increasing interest in mental health disciplines, particularly among conditions characterized by social distinctiveness (Hinterbuchinger et al., 2018). This growing interest arises from the recognition that decision-making is a fundamental component of social functioning (Sanfey, 2007), especially within conditions such as autism. Autistic children and adolescents often exhibit distinct patterns of social communication and interaction. Given these unique social characteristics, understanding decision-making processes during social interactions in the autistic population is crucial. Despite the abundant existing literature, research on decision-making in autism has produced conflicting findings regarding socially cooperative and selfish decisions (e.g. Hartley & Fisher, 2018; Hase et al., 2023; Townsend et al., 2021; Woodcock et al., 2020). Moreover, previous studies have often focused on the resulting behavior of the decision (response) and less on the decision-making process itself. To address this gap, the present study examined both explicit (observable responses) and implicit (response times (RTs)) measures to clarify the underlying decision-making behavior among autistic children and adolescents. Specifically, we employed the Ultimatum Game (UG) and the Dictator Game (DG), two interactive tasks frequently used to study decision-making processes. In addition, executive functions (EFs) were examined to explore their association with decision-making. By measuring decision responses, RTs, and executive functioning, the present experiment provides a comprehensive examination of the deliberative aspects of decision-making and sheds light on how various fairness scenarios influence decisions in autistic children and adolescents.

The UG and DG are economic bargaining games where a sum of money must be allocated between two players—specifically, a proposer and a responder. In the UG, the proposer makes an offer on how to split the money, and the responder chooses whether to accept or reject the offer. If the responder accepts, both players receive the agreed amount, demonstrating cooperative prosocial behavior from the responder's stance; however, rejecting the offer results in no gain for either party. On the other hand, in the DG, the proposer decides how to distribute the money, and the responder must accept the offer. The DG allows researchers to study either a *selfish* preference to keep more money or a prosocial preference to offer more to others (Leder & Schütz, 2018; Van Dijk & De Dreu, 2021). In the present study, participants took the role of the responder in the UG and the proposer in the DG. Offers were categorized from the participants' perspective as either: (1) fair (a 50:50 split); (2) selfish/ultra-fair (where the participant earns more than half); or (3) selfless/unfair (where the participant earns less than half)—note that the terms "selfish" and "selfless" are used to refer to the behavior of accepting ultra-fair and unfair offers, respectively.[1] According to game theory (Nowak et al., 2000), rational decisions to maximize one's gains would involve accepting all offers as a responder in the UG, which reflects cooperative prosocial behavior, and proposing the least amount of money in the DG, which reflects selfish behavior. However, prior research with samples from the general population has shown that individuals generally tend to reject unfair offers in the UG due to the negative emotions elicited by unfair treatment, resulting in irrational (e.g. aversion to inequality) or emotional (i.e. altruistic punishment) non-cooperative decisions (Chen et al., 2021; Sanfey et al., 2003; Zheng et al., 2017). In addition, in the DG, participants tend to make the most economically rational decision by proposing ultra-fair offers (from the proposer's stance) to a higher percentage than fair and unfair offers (Engel, 2011).

Various theories can be applied to explain autistic decision-making within the context of the UG and DG. First, the Theory Of Mind (ToM) hypothesis suggests that autistic individuals face challenges in understanding the implicit intentions of others and attributing others' mental states (Baron-Cohen, 2000; Baron-Cohen et al., 1985). This implies that in economic bargaining games, autistic individuals may struggle to recognize others' emotional aversion to inequality. While the ToM hypothesis has frequently been used as a framework for autism research, recent studies have shown that additional cognitive functions may also influence decision-making in autism. Apperly and Butterfill (2009) proposed a dual-system model of ToM, suggesting that individuals employ two distinct cognitive systems for understanding others' mental states: an automatic (implicit) system and a reflective (explicit) system. This dual-system concept has been applied to autism research through the dual-process theory (e.g. see Hartley & Fisher, 2018; Jin et al., 2020; Townsend et al., 2021; Woodcock et al., 2020). The dual-process theory (Brosnan et al., 2016; Evans, 2011) proposes that an intuitive emotional process can be coupled with rational cognitive processes when applied to decision-making. While the intuitive process is fast, automatic, and emotional, the rational cognitive process is slow, deliberative, and dependent on EFs (Brosnan et al., 2016; Demetriou et al., 2019; Evans, 2010; Pérez-Lalama et al., 2020; Shiri et al., 2018). A growing body of research suggests that autistic populations tend to inhibit the influence of intuitive processing, favoring more deliberative processing determined by tangible outcomes (Brosnan et al., 2016; Evans, 2011), such as rational decisions in the UG and DG games to optimize the overall outcome. This inclination results in a diminished reliance on social heuristics and a slower decision-making process (Brosnan et al., 2016; Evans, 2011; Isler et al., 2021; Jin et al., 2020).

Previous research on decision-making focused on understanding two types of explicit behaviors (Sodian et al., 2015; van der Plas et al., 2023). On the one hand, cooperative prosocial behavior is observed when participants accept fair offers or sacrifice their own self-interest to accept unfair offers in the UG and ensure that both players receive a monetary amount. On the other hand, selfish behavior is observed when a participant proposes unfair offers in the DG to maximize their own earnings (Miraghaie et al., 2022; Paulus & Rosal-Grifoll, 2017; Sally & Hill, 2006; Schmitz et al., 2015). For instance, when examining responses in the UG, several studies found that autistic children and adolescents exhibited more cooperative prosocial behavior than their non-autistic peers by accepting more unfair offers (less than half of the total; Jin et al., 2020; Sally & Hill, 2006; Schmitz et al., 2015; Wang et al., 2019). Conversely, in a study by Woodcock et al. (2020), autistic adolescents accepted fewer unfair offers, reflecting non-cooperative behaviors. When selfish behavior was examined in the DG, Paulus and Rosal-Grifoll (2017) observed that autistic children offered more unfair offers (unfair to them and ultra-fair to the other participants) as proposers than non-autistic peers. This selfless behavior was also confirmed by Hase et al. (2023) and Schmitz et al. (2015), even though in the latter-mentioned study, the authors also found a contradictory preference in autistic children and adolescents to offer selfish/ultra-fair amounts, unlike the non-autistic group that offered fair amounts. However, other studies found no across-group differences in the DG, where both tended to offer fair amounts (Sally & Hill, 2006). Despite the contradictory decision-making behaviors noted in autism, when the underlying processes were examined, Jin et al. (2020) and Woodcock et al. (2020) identified a connection between better EF skills and greater cooperative prosocial behavior in autistic participants—this was explained as a way to secure a monetary gain and maximize the possible earnings by the end of the game. Thus, it is challenging to deduce the implicit processes (intuitive, emotional process vs rational, cognitive process) in which autistic children and adolescents demonstrate cooperative or selfish behaviors.

A dependent variable that reflects implicit processes and can provide valuable insights into participants' intuition and deliberation in their responses is RT (Alós-Ferrer et al., 2016). In a prior study by Ikuse et al. (2018), autistic adults showed slower RTs and distributed more money than non-autistic adults in a modified version of the UG. The version of the UG used by Ikuse et al. (2018) had participants take only the role of the proposer and were presented with distinct background conditions, in which responses were algorithmically determined. While Ikuse et al.'s (2018) findings with adult participants are informative, we should note that autistic adults generally show slower RTs than non-autistic adults and can learn to compensate for non-adaptive decision-making behaviors (see Livingston et al., 2019; Zapparrata et al., 2023). Furthermore, small variations in the design of economic bargaining games can change participant's behaviors (see Houser & McCabe, 2014). For these reasons, in our study, we focused on autistic children and adolescents because it is a critical developmental stage for social functioning that might benefit from specific and targeted support. In addition, to reduce the variability across the potentially different versions of the UG and DG, we applied a previously employed design (e.g. see Jin et al., 2020; Wang et al., 2019) to gather a complete picture of decision-making processes in autism. To achieve this objective, our study presented computerized versions of both the UG and the DG, allowing us to accurately register participants' RTs. Thus, our study builds upon previous research conducted by Jin et al. (2020) and Wang et al. (2019) with the novelty of including the DG and incorporating the measurement of RTs as an implicit marker of decision-making processes. In addition, as in previous research with these paradigms (Jin et al., 2020; Woodcock et al., 2020), we also measured EF to obtain an additional dimension of cognitive processes that could be correlated with implicit and explicit decision-making behaviors (Carlson et al., 2013). A free distribution task was also applied to assess decision tendencies in a condition without predefined fairness conditions.

Based on the theories discussed above, it was possible to make some specific predictions. First, it was hypothesized that decision-making in autistic children and adolescents would be based on rational (deliberative, reflective) cognitive processes rather than intuitive (emotional) processes, resulting in higher rates of accepting unfair distributions as responders in the UG and higher rates of proposing unfair distributions as proposers in the DG, compared to non-autistic participants. This outcome would align with the ToM hypothesis and dual-process theory, which explain an autistic difference when predicting others' mental states regarding offers and a preference for rational reasoning (Baron-Cohen, 2000; Baron-Cohen et al., 1985; Brosnan et al., 2016; Evans, 2010; Jin et al., 2020; Nowak et al., 2000; Wang et al., 2019). Second, it was expected that autistic children and adolescents would exhibit slower RTs in the UG and DG (i.e. slower decision-making) than non-autistic peers. Interestingly, it was expected that RTs will vary depending on the conflicting nature of the presented decision, in particular when comparing ultra-fair/unfair versus fair scenarios. This outcome would provide an observation of the implicit process in autistic decision-making, support the dual-process theory by indicating a more prominent deliberative process, and provide information on an underlying process influencing social functioning (Brosnan et al., 2016; Evans, 2010;

Ikuse et al., 2018). Third, while it was anticipated that EFs would influence decision-making, the specific nature of this relationship was approached as exploratory due to the limited empirical evidence and the complex interplay of EF components. It was expected that better EF would be associated with more rational decisions (i.e. decisions that maximize financial gain) and less intuitive decisions in autistic children and adolescents (Demetriou et al., 2019; Jin et al., 2020; Jones et al., 2018; Nowak et al., 2000; Woodcock et al., 2020; see also Polónyiová et al., 2024 for more information on how ToM and EF may relate).

Methods

Participants

A statistical power analysis was carried out using G*Power software (Faul et al., 2007) to determine the required sample size for detecting a medium-sized interaction effect ($f=0.25$) in a repeated measures analysis of variance (ANOVA) with a within-between interaction. The required sample size for detecting a two-way interaction effect with a partial eta squared of 0.06 and power $(1-\beta)=0.95$ (Cohen, 2013) in a repeated measures ANOVA with a within-between interaction. Specifically, the power analysis focused on the interaction between Justice (a within-subjects factor with three levels: ultra-fair, fair, and unfair) and Group (a between-subjects factor with two levels: autistic vs non-autistic). This interaction represented the primary focus of the study, aimed at determining whether autistic and non-autistic children differ in their justice decisions during economic bargaining games. The assumed effect size (partial eta squared$=0.06$, which corresponds to $f=0.252$) was consistent with findings from previous studies (Jin et al., 2020; Woodcock et al., 2020). For example, Woodcock et al. (2020) examined interactions between group and decision-making variables and found medium-to-large effects for group differences in UG offers ($d=0.66$, corresponding approximately to $f=0.467$), as well as smaller interaction effects for the acceptance rates of unfair offers ($d=0.25$, approximately $f=0.177$). Similarly, Jin et al. (2020) reported interaction effects between group and decision-making responses in acceptance rates of unfair offers, with an effect size of $d=0.71$ (equivalent to $f=0.502$). These previous studies support assuming the medium effect size in the current study. With $\alpha=0.05$, power $(1-\beta)=0.95$, and a non-sphericity correction of 1, our analysis indicated that 42 participants would be required. We, therefore, recruited a sample of 51 participants to ensure sufficient power to detect the hypothesized interaction effects and effectively address our research goal.

The 51 participants included in the study consisted of 25 autistic and 26 non-autistic children and adolescents, aged between 8 and 18 years and matched for age, sex, and intelligence quotient (IQ). Most participants in the autistic group were males (87.5%; see Lockwood Estrin et al., 2021), and this percentage was maintained in the non-autistic group to ensure balance. None of the participants were at risk of social exclusion; they all had access to services and goods (e.g. food, education, housing, health care, and transportation) to participate in society and in this study (Azmat, 2020).

Autistic participants were recruited through local associations and clinical referrals, while non-autistic participants were recruited through schools and community contacts. Parents of children and adolescents interested in participating consented to the local associations or professionals to share their contact information with our research team. Subsequently, our team contacted the parents, provided information sheets, explained the research study, and scheduled an evaluation date. Part of the research team are professionals working daily with autistic individuals, reflecting the engagement of the researchers with the autistic community and the high willingness of the autistic community to participate in this study. There was no other community involvement in this work. The hospital's Research Ethics Committee approved the study, and all procedures aligned with the 1964 Declaration of Helsinki. All participants over 12 years of age and their parents provided signed consent; participants under 12 years gave verbal assent and their parents signed the consent form. Given the sensitive nature of the study questions, consent for sharing data on individual characteristics was not sought; however, anonymized task performance data are available in the repository: https://osf.io/svrdk/?view_only=ce60f73d9e3e4e17aa7fd52b4faf7526.

Autistic participants were included if they were previously diagnosed with autism spectrum disorder (ASD) by a psychiatrist or clinical psychologist. A qualified clinical psychologist confirmed the diagnosis through interviews with parents using the Autism Diagnostic Interview-Revised (ADI-R; Rutter et al., 2003). Moreover, parents of both groups completed the Child Behavior Checklist (CBCL/6-18; Achenbach & Edelbroch, 1991). In the CBCL, *T*-scores equal to or above 70 indicate clinically significant behavioral difficulties.

According to parent reports and reviews of medical records, both autistic and non-autistic participants were excluded if they met any of the following criteria: (1) language impairments (scores $\leqslant 80$ on the Kaufman Brief Intelligence Test (K-BIT)'s verbal domain (Kaufman and Kaufman, 1990); (2) low academic performance (i.e. repeating a school year or IQ scores $\leqslant 80$ as measured by the K-BIT); (3) history of neurological diseases; (4) co-occurring conditions in the case of autistic individuals (e.g. Attention-Deficit/Hyperactivity Disorder [ADHD]); (5) psychiatric history or significant behavioral problems (*T*-scores $\geqslant 70$ on any CBCL domain) in the case of non-autistic individuals; (6) medication use (i.e. corticosteroids); or (7) any medical condition affecting cognition. Please see the flow diagram in Figure 1 for the inclusion process.

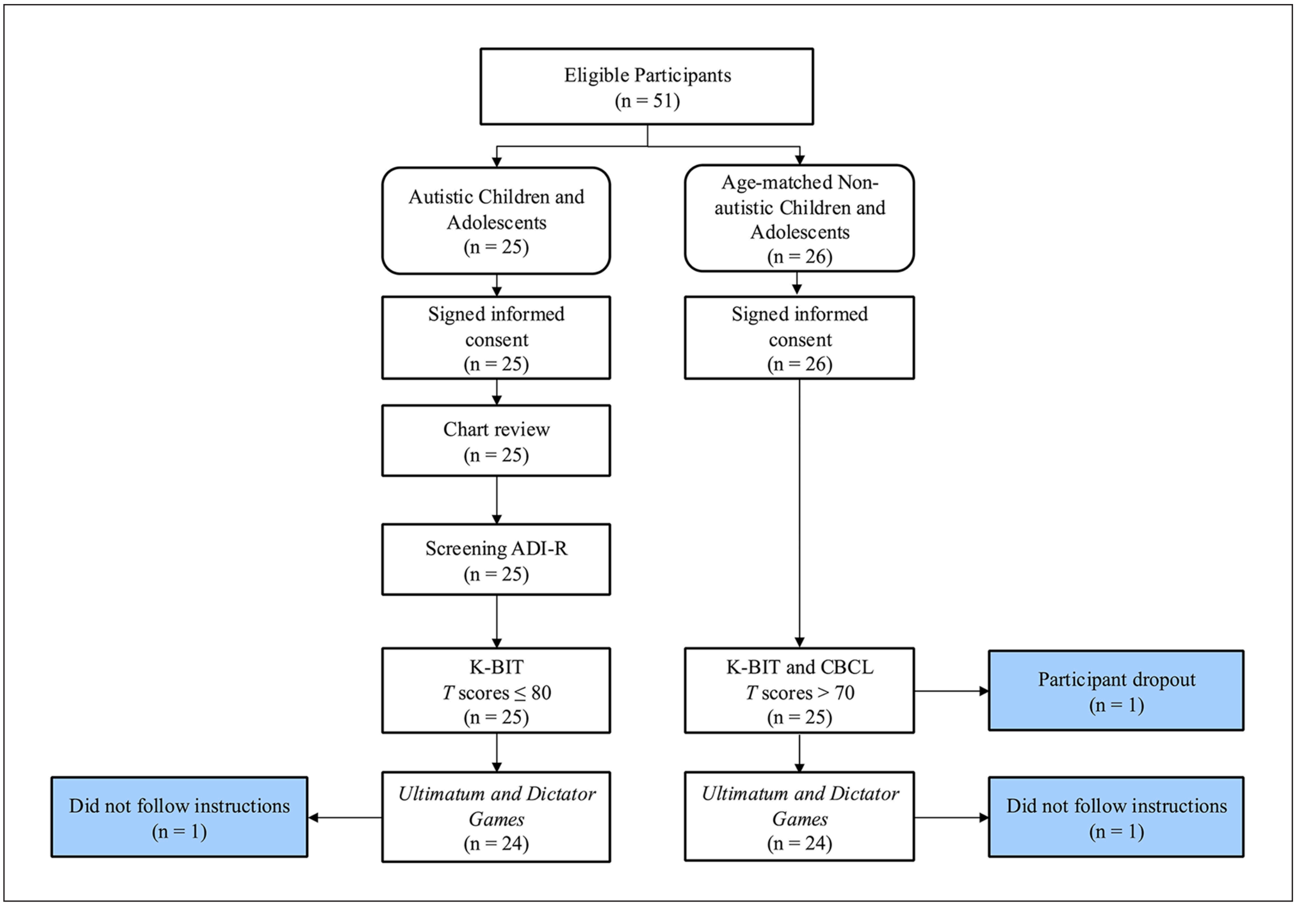

Figure 1. Selection process.

Materials

Behavior Rating Inventory of Executive Function. The Behavior Rating Inventory of Executive Function (BRIEF; Gioia et al., 2010) Parent Form assesses EF difficulties in children and adolescents aged 5 to 18 years. In this study, we used the BRIEF (Belmonte Maldonado et al., 2016), which includes 86 items measuring eight EFs (inhibit, shift, emotional control, initiate, working memory, plan/organize, organization of materials, and monitor). Each item is scored on a 3-point Likert-type scale (1 = never, 2 = sometimes, and 3 = often). Raw scores can be transformed into T-scores, with scores $\geqslant 70$ indicating clinically elevated difficulties in the EF scales.

Ultimatum and Dictator Games. The UG and DG are behavioral economics experiments that study interpersonal decision-making strategies: cooperation and selfish behavior (Forgas & Tan, 2013; Güth et al., 1982). In these game paradigms, a monetary amount is divided between the participant and another player. Participants are assigned either the role of the proposer or the role of the responder. The proposer is the one who makes a one-time offer on how to split the monetary amount, while the responder is the one who accepts or rejects the offer. In the UG, if the responder accepts the offer, both players earn the accorded amount, but if the responder rejects it, none earn anything (Güth et al., 1982). As a result, the UG allows us to measure cooperation (e.g. accepting all offers to ensure that both players will earn the amount; Nowak et al., 2000). In the DG, on the other hand, the proposer makes an offer, aware that it can be as much or as little as they want, given that the responder must accept any offer they receive. The DG allows measuring altruistic, cooperative behavior (Leder & Schütz, 2018).

Participants in the present study played against a hypothetical player and were assigned the roles of the responders in the UG and proposers in DG. We chose to assign participants only one role per game to minimize confusion in instructions, keep the task duration brief, and eliminate redundancy in the design. The games were administered as computerized tasks using DMDX (Forster & Forster, 2003) or virtually using PsychoPy (Peirce et al., 2019). The tasks were displayed on a white screen with a black, size 12, Courier New font. The instructions were concisely written and thoroughly reviewed by experienced researchers to ensure clarity and understanding for all participants.

Table 1. Offers presented in the Ultimatum Game and Dictator Game divided by fairness.

Unfair	Fair	Ultra-fair
24 parts for them, 6 parts for you	10 parts for them, 10 parts for you	2 parts for them, 8 parts for you
8 parts for them, 2 parts for you	15 parts for them, 15 parts for you	4 parts for them, 16 parts for you
16 parts for them, 4 parts for you	5 parts for them, 5 parts for you	6 parts for them, 24 parts for you

In addition, after reading the instructions, participants were asked if they understood the game instructions before starting the games. The games had nine trials each, following Wang et al.'s (2019) design. In each trial, an offer was presented on the computer screen and was expressed in proportions (e.g. "10 parts for them, 10 parts for you"). The offers represented three conditions: (1) fair (i.e. an equal amount was distributed between the participant and the hypothetical player); (2) unfair (i.e. earnings will be less than 50% of the amount of money for the participant); and (3) ultra-fair (i.e. earnings will be more than 50% of the amount of money for the participant). The specific offers presented in the games can be found in Table 1. The order of each offer was randomized in each game.

Before the UG began, participants received the following instruction:

> A person has to split €100 between them and you. They will only make a single and final offer. You can accept or reject their offer. Press the M key to accept and the Z key to reject. If you reject, neither of you will win anything. If you accept, the money will be distributed according to the proposal. When you are ready, press SPACE to start.

Once they pressed the spacebar, a fixation point (X) was presented on the center of the computer screen (2000 ms), which was replaced by the offer (6000 ms) and then by a screen where participants were instructed to respond (6000 ms). This allowed participants to read the offer and think about their decision without jumping to conclusions. The DG was designed parallel to the UG, but the instructions differed. For the DG, participants received the following instruction:

> Now you have to divide 100€ between yourself and another person. Unlike the previous game, the other person will not accept or reject the offer, but they will directly receive the amount of money you offer. Press the M key if you would endorse the displayed offer or the Z if you would NOT endorse that offer. When you are ready, press SPACE to start.

These instructions and the codes for both tasks can be found in the Supplemental Material and online repository. The UG and DG were presented in a fixed order. Afterward, an additional free distribution task was administered, in which participants were asked, "If you had 100€, how much, if any, would you give to the hypothetical player? The other player will accept no matter the offer." This task consisted of a single trial with no pre-set conditions or offers that could influence participants' responses.

Procedure

Upon verbal agreement to participate in the study, appointments were scheduled for the experimental sessions, either in a quiet and private room in the hospital (for in-person sessions) or at the participants' homes (for virtual sessions). Upon arrival at the appointment, participants and their parents were greeted and guided to the experimental room. Participants and their parents were briefed that the experimental session would take place in the current room, that the parents would be with a colleague in a separate adjacent room, and that they would meet again at the end of the experiment. In addition, participants were reminded of the nature of the tasks in which they would be asked to answer some questions about words and figures and make decisions in computerized tasks. Importantly, participants were assured that we could contact their parents at any point during the session, although no participant requested this option during testing.

After obtaining signed consent, parents from the experimental group were interviewed by a trained clinical psychologist to complete the ADI-R. Parents then completed the CBCL and BRIEF questionnaires. Meanwhile, participants were assessed by a trained research psychologist and psychology student, who remained in the room with the participants throughout the entire testing session. The K-BIT was applied at the beginning of the assessment session, followed by the computerized decision-making tasks (UG and DG) on a laptop. In virtual sessions, parents were asked to step out of the room to minimize distractions; then, the K-BIT and computer tasks were administered online. Participants were instructed to use the "Z" and "M" keys to respond to on-screen questions and were provided with clear instructions, with researchers on hand for questions. Researchers did not disclose that the task's objective was to maximize earnings and could not observe participants' responses during testing. The UG and DG were administered in person using the DMDX software or virtually using PsychoPy's Pavlovia. Finally, the free distribution task was applied. The entire assessment lasted approximately 30 min, with the UG, DG, and free distribution tasks taking about 10 min.

Data analysis

In the descriptive analysis for each group, the categorical variables are indicated by the absolute (*n*) and the relative (%) frequency. The *p*-values were calculated via chi-square tests, while the quantitative variables were expressed by the mean (*M*). The standard deviations (*SDs*) and the *p*-values were estimated by the Student's *t*-test. To study probabilities to endorse the offers (i.e. acceptance rates of the offers in the UG and endorse rates of the offers in the DG) and RTs, an ANOVA was performed, focusing on the Justice × Group interaction, which was central to our hypotheses. Group (Autistic and Non-autistic) was included as a between-subject factor, and Dilemma (UG and DG) and Justice Condition (Fair, Unfair, and Ultra-Fair) were included as within-subject factors. To remove the variability caused by fast guesses in the RTs, we excluded those RTs less than 250 ms (see for similar procedures García-Blanco et al., 2016; Ghosn et al., 2019). This exclusion comprised 0.93% of all responses for the autistic group and 0.23% for the non-autistic group. Moreover, the distribution difference between the autistic and non-autistic groups in the free distribution of money was analyzed in a univariate ANOVA. Finally, an exploratory correlation analysis was conducted to test which potential EF components (e.g. inhibition, working memory, cognitive flexibility) most strongly influences decision-making responses. Specifically, this analysis examined associations between significant decision-making responses identified in previous analyses and BRIEF scores within the Autistic group. The statistical analyses were performed using IBM SPSS Statistics software (version 25).

Results

The descriptive data are presented in Table 2. Both groups were similar in sex, age, school years, and IQ (all $ps > 0.558$), and differed only in the subscales of the BRIEF test (all $ps < 0.007$; see Table 2).

Table 3 shows the probability of endorsing offers and the mean RTs for each group in both games and all three justice conditions. Since the recruited participants varied widely in age, we conducted an initial exploratory analysis and only found that for ultra-fair offers, older participants tended to make slower responses (see Supplemental Material). Since this pattern was the same in both groups, for simplicity, we present the statistical analyses using the three factors cited above.

Probability to endorse offers in economic bargaining games (UG and DG)

The ANOVA showed a significant effect of Justice, $F(2, 92) = 96.05$, $p < 0.001$, $\eta_p^2 = .676$, and a significant Dilemma × Justice × Group interaction, $F(2, 92) = 9.00$, $p < 0.001$, $\eta_p^2 = .164$. No other effects approached significance (all $ps > 0.10$; see Figure 2).

To study the three-way interaction, we examined the effects of Group and Justice for each Dilemma. For the UG, we found an effect of Justice, $F(2, 92) = 77.41$, $p < 0.001$: the probability of endorsing offers was higher in the Fair condition than for the other conditions (+31%, $p = 0.026$, compared to the Ultra-Fair condition; and +74%, $p < 0.001$, compared to the Unfair condition). Moreover, the probability of endorsing offers was higher in the Ultra-Fair condition than in the Unfair condition (+42%, $p = 0.001$). Neither the effect of Group nor the Group × Justice interaction approached significance (all $Fs < 1$).

For the DG, we did not find an effect of Group ($F < 1$), but we found an effect of Justice, $F(2, 92) = 79.93$, $p < 0.001$, which was qualified by a Group × Justice interaction, $F(2, 92) = 4.99$, $p = 0.009$. To examine this interaction, the effect of Group was analyzed for each condition of Justice. The effect of Group occurred in the Ultra-Fair condition, $F(1, 46) = 5.02$, $p = 0.030$, $\eta_p^2 = .098$: Autistic children and adolescents had a lower probability of endorsing Ultra-Fair offers compared to non-autistic children and adolescents (–28%). No other between-group differences were found (all $ps > 0.117$).

RT in economic bargaining games (UG and DG)

The ANOVA revealed faster RTs in the UG than in the DG, $F(1, 46) = 6.75$, $p = 0.013$, $\eta_p^2 = .128$, and a main effect of Justice ($RT_{Ultra\text{-}fair} > RT_{Fair} > RT_{Unfair}$), $F(2, 92) = 16.86$, $p < 0.001$, $\eta_p^2 = .268$. Importantly, we also found a significant Justice × Group interaction, $F(2, 92) = 5.99$, $p = 0.004$, $\eta_p^2 = .115$. No other effects were found (all $ps > 0.159$).

To examine the Justice × Group interaction, we analyzed the effect of Group for each Justice Condition. This interaction showed an effect of Group in the Ultra-Fair condition, $F(1, 46) = 4.72$, $p = 0.035$, $\eta_p^2 = .093$: Autistic participants spent more time before giving a response than non-autistic participants when they had to endorse ultra-fair offers (+375 ms). No other differences were found (all $ps > 0.320$; see Figure 3).

Free distribution task

When participants were asked how they would freely distribute the money, we found no significant differences in the average monetary amount offered between individuals of the autistic group ($M = 40.14$; $SD = 15.42$) and the non-autistic group ($M = 34.43$; $SD = 18.87$, $F(1, 43) = 1.19$, $p = 0.281$).

Exploratory associations between responses and EFs

A Pearson correlation was calculated to examine relationships between the variables that significantly differed from the non-autistic group (i.e. lower probability of

Table 2. Demographic characteristics and clinical data of participants (autistic and non-autistic).

	Autistic ($n=24$)		Non-autistic ($n=24$)		p
	M	*SD*	*M*	*SD*	
Female participants (*n* (%))	3 (12.50%)		3 (12.50%)		0.667
Age	13.63	2.65	13.71	3.09	0.921
Education level (*n* (%))					
Primary school	8 (33.33%)		7 (29.17%)		0.587
Secondary school (including high school)	12 (50.00%)		15 (62.50%)		
College or university	4 (16.67%)		2 (8.33%)		
CBCL total raw scores					
Anxious/depressed	9.29	5.18	3.88	4.11	<0.001
Withdrawn/depressed	7.42	4.18	2.13	2.19	<0.001
Somatic complaints	4.50	3.63	1.83	2.32	0.004
Social problems	10.00	4.62	1.63	2.45	<0.001
Thought problems	5.75	4.32	1.13	1.26	<0.001
Attention problems	11.00	4.49	3.17	2.63	<0.001
Rule-breaking behavior	4.71	3.56	1.88	2.19	0.002
Aggressive behavior	11.08	6.22	4.79	4.85	<0.001
Other	6.38	2.76	4.08	2.36	0.003
Total score	68.63	27.02	24.50	19.35	<0.001
K-BIT total *T*-scores					
Verbal index	103.60	11.33	102.83	9.15	0.871
Manipulative index	104.84	12.43	105.08	10.27	0.945
Total score	101.60	12.18	102.00	9.33	0.934
BRIEF total raw scores					
Inhibit	9.63	5.08	2.92	3.32	<0.001
Shift	11.79	3.55	3.42	3.12	<0.001
Emotional control	11.92	4.75	3.88	3.97	<0.001
Initiate	8.79	2.67	3.17	2.73	<0.001
Working memory	13.25	4.35	4.13	4.04	<0.001
Plan/organize	17.46	4.58	5.99	4.54	<0.001
Organization of materials	9.08	3.23	4.71	3.29	<0.001
Monitor	11.83	2.58	4.00	3.01	<0.001
ADI-R scores					
Reciprocal social interactions	17.13	5.35			
Language/communication	15.08	4.71			
Repetitive behaviors/interests	6.63	2.79			
Evidence of onset before 36 months of age	3.25	1.54			

Autistic = autistic children and adolescents; non-autistic = non-autistic children and adolescents; CBCL = Child Behavior Checklist; K-BIT = Kaufman Brief Intelligence Test; BRIEF = Behavior Rating Inventory of Executive Function; ADI-R = Autism Diagnostic Interview-Revised. The *p*-values correspond to chi-square test for female participants and educational level and to one-way ANOVA for the rest of the variables.

endorsing ultra-fair offers in the DG and slower RTs in ultra-fair conditions) and executive functioning (BRIEF subscale scores) in autistic participants. The lower probability of endorsing ultra-fair offers in the DG was associated with better organization of materials skills ($r=.553$, $p=0.005$). In addition, slower RTs for accepting or endorsing ultra-fair offers showed a small association with cognitive-shifting abilities ($r=-.413$, $p=0.045$), although this latter correlation should be interpreted cautiously, as it may not withstand correction for multiple comparisons (see Table 4).

Discussion

The present study examined the underlying explicit (responses) and implicit (RTs) processes behind decision-making in autism, particularly involving a deliberative process and EFs when autistic participants face selfish conditions. The main findings are as follows. First, concerning the probability of endorsing offers (explicit measurement), autistic children and adolescents were less likely to endorse selfish offers (i.e. ultra-fair offers) in the DG than non-autistic children and adolescents. Related to

Table 3. Descriptive data of the probability to endorse offers and response times in the Ultimatum and Dictator Games: comparing experimental conditions (fair, unfair, and ultra-fair) across autistic and non-autistic groups.

Experiment			Autistic (*n* = 24)		Non-autistic (*n* = 24)	
	Variables	Conditions	*M*	*SD*	*M*	*SD*
Ultimatum Game	Probability to endorse offers (%)	Fair	95.83	11.26	90.97	19.02
		Unfair	8.33	24.57	16.67	34.05
		Ultra-fair	62.5	46.43	59.03	45.04
	Response times (ms)	Fair	1327	724	1564	761
		Unfair	1264	652	1203	526
		Ultra-fair	1947	739	1368	673
Dictator Game	Probability to endorse offers (%)	Fair	95.83	14.95	84.72	30.66
		Unfair	9.72	25.02	5.56	21.23
		Ultra-fair	41.67	44.23	69.44	41.61
	Response times (ms)	Fair	1009	546	1089	622
		Unfair	1090	716	1100	735
		Ultra-fair	1611	869	1441	812

Autistic = autistic children and adolescents; non-autistic = non-autistic children and adolescents.

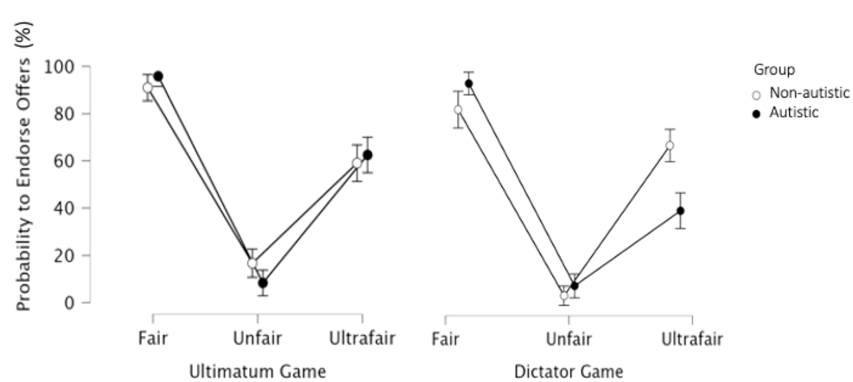

Figure 2. Probability of endorsing offers (%) in the Ultimatum and Dictator Games among autistic and typically developing children and adolescents.

this finding, a low probability of endorsing selfish offers in the DG was associated with better scores on the organization of materials subscale of the BRIEF questionnaire (i.e. autistic participants with better organizational skills offered less selfish amounts). Second, regarding the analyses of the RTs (implicit measurement), autistic children and adolescents showed slower RTs when accepting and proposing selfish (ultra-fair) offers in both the UG and DG, compared to non-autistic participants. This deliberative response was associated (albeit weakly) with higher cognitive-shifting abilities. Finally, when participants were asked how they would freely distribute the money, both autistic and non-autistic participants offered fair distributions. The following paragraphs discuss these findings in relation to current theories and prior research.

Regarding the probability of endorsing offers in the UG and free distribution task, our data revealed that autistic and non-autistic participants behaved similarly, showing a notable preference for accepting fair offers and rejecting unfair offers in the UG. According to previous research in the general population, individuals tend to reject unfair offers due to the negative emotions elicited by the unfair treatment (Sanfey et al., 2003), placing a greater value on equality (Chen et al., 2021; Güroğlu et al., 2010; Kaltwasser et al., 2016). Thus, the lower rates of cooperative prosocial behavior (i.e. lower rates of accepting unfair offers) may indicate that decision-making was influenced by an emotional aversion to inequality as an intuitive process rather than by a drive for tangible outcomes (Brosnan et al., 2016; Nowak et al., 2000). Despite deviating from traditional notions of

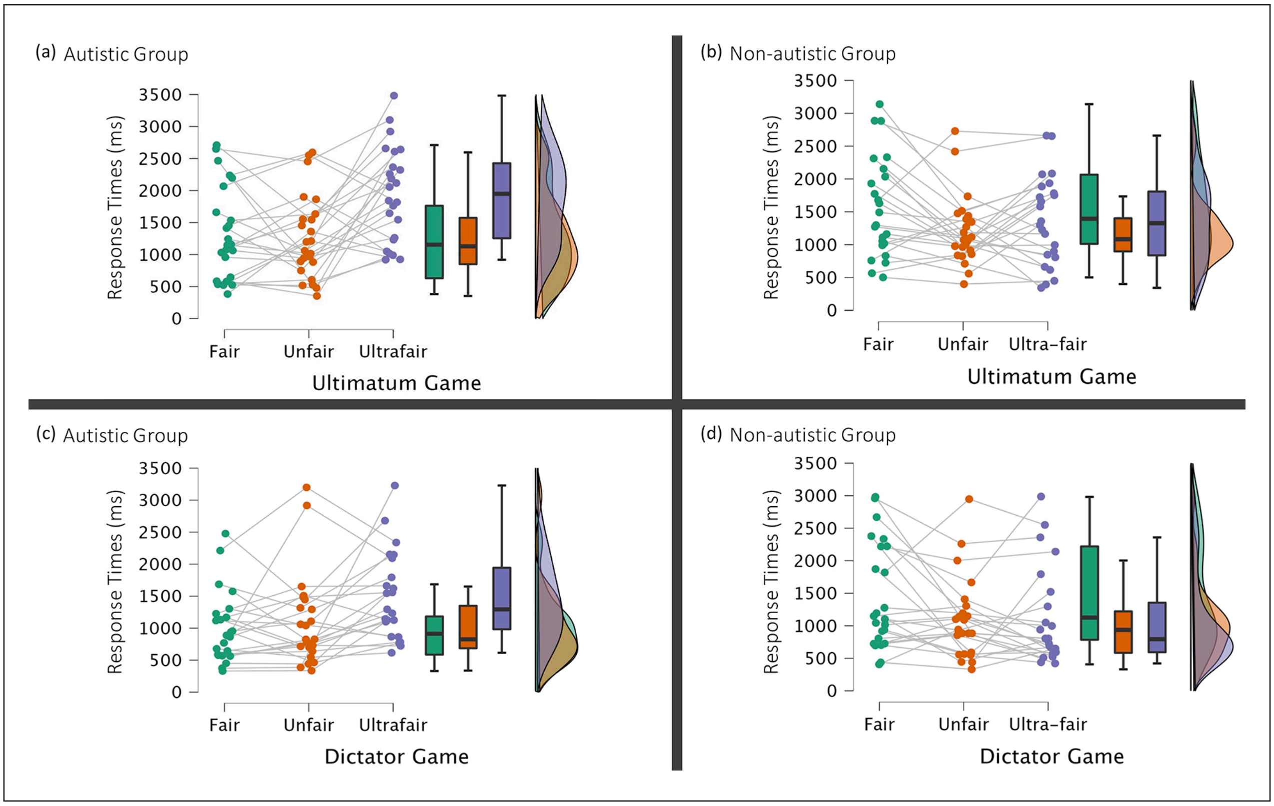

Figure 3. (a) Response times (ms) of autistic children and adolescents in the Ultimatum Game; (b) response times (ms) of typically developing children and adolescents in the Ultimatum Game; (c) response times (ms) of autistic children and adolescents in the Dictator Game; (d) response times (ms) of typically developing children and adolescents in the Dictator Game.

Table 4. Correlation results for significant responses in the experimental tasks and executive functions in the autism group.

Variable		Mean RTs in ultra-fair conditions	Probability to endorse ultra-fair offers in Dictator Game
1. BRIEF inhibit	*r*	−.176	.227
	p-value	0.410	0.285
2. BRIEF shift	*r*	−.413	.131
	p-value	**0.045**	0.540
3. BRIEF emotional control	*r*	−.274	.141
	p-value	0.196	0.510
4. BRIEF initiate	*r*	.144	−.058
	p-value	0.503	0.787
5. BRIEF working memory	*r*	.040	.162
	p-value	0.852	0.449
6. BRIEF plan/organize	*r*	−.062	.238
	p-value	0.773	0.263
7. BRIEF organization of materials	*r*	−.086	.553
	p-value	0.689	**0.005**
8. BRIEF monitor	*r*	−.197	.330
	p-value	0.357	0.115

BRIEF = Behavior Rating Inventory of Executive Function; RTs = response times. Bold values indicate $p < .05$.

rational economic decision-making (Nowak et al., 2000), this tendency to reject unfair offers as a responder may reflect an adaptive social-moral value in both autistic and non-autistic participants (Hoffman et al., 2008).

In the DG, autistic children and adolescents were less likely to propose selfish offers (i.e. ultra-fair offers) than non-autistic peers. In other words, autistic participants were less likely to propose offers in which they would be the most benefited player out of the two, which is economically irrational and contrary to the predictions of the ToM hypothesis and game theory (Baron-Cohen, 2000; Nowak et al., 2000). Despite variations in design, a higher probability of selfless responses has been observed in other studies with autistic children (Paulus & Rosal-Grifoll, 2017; Schmitz et al., 2015) and autistic adolescents (Hase et al., 2023). This behavior has often been associated with social anxiety or avoidance of social rejection (Hase et al., 2023); however, this behavior may also stem from other factors such as stronger sociomoral rules regarding justice (Dempsey et al., 2020; Peterson & Wellman, 2022). Notably, the autistic tendency to propose fewer ultra-fair offers implies that they take into consideration the other person's interests and are aware of the potential adverse effect of unjust offers on others, which aligns with moral principles of fairness perception (see Peterson & Wellman, 2022 for sociomoral strengths in autism). Consequently, the decisions observed in the DG may contribute to social functioning skills that, when applied in the right contexts, could be socially esteemed.

Critically, when measuring RTs as a marker of the implicit process underlying autistic decision-making, our findings revealed a distinctive pattern between groups in both games. On the one hand, autistic participants behaved similarly to their non-autistic peers when making decisions regarding fair and unfair distributions. On the other hand, autistic participants showed slower RTs than non-autistic peers when presented with selfish (ultra-fair) offers, irrespective of the game. These findings in the ultra-fair conditions align with the dual-process theory (Brosnan et al., 2016; Evans, 2011), which suggests that a more rational cognitive process in autistic individuals would result in slower decision-making compared to non-autistic peers (see Chamberlain et al., 2023; Zapparrata et al., 2023 for reviews of RTs in autism). Previous research measuring RTs in autistic adults with a different version of the UG reported that autistic participants exhibited slower RTs across all their background conditions (Ikuse et al., 2018); however, their design did not differentiate results across fairness decisions. In our study, the observed slower RTs, evident only when participants received more than half of the total amount, suggest that autistic children and adolescents may prioritize selfless prosocial behaviors driven by heightened sociomoral principles that favor fairness (Peterson & Wellman, 2022) over intuitive responses compared to their non-autistic peers. This rational cognitive process appears to be contingent on deliberating the moral outcomes of the decision.

In addition, for autistic participants, we examined the relationship between selfless responses and RTs in the DG with EFs (using the BRIEF subscales; Hendrickson & McCrimmon, 2019). The results showed that selfless responses in the DG were positively associated with better EFs related to organizational abilities ($r=.553$). In other words, the ability to maintain order and easily find items was correlated with selfless behavior. However, in general, EFs in autistic children and adolescents were not related to maximizing one's own financial benefit (see also Demetriou et al., 2019; Jones et al., 2018). One explanation for this pattern is that proposing fewer selfish offers and slower RTs during ultra-fair decision-making may reveal an increased deliberation in a scenario that could be emotionally conflicting. This deliberation may result in accepting ultra-fair offers because it was the decisions made by others (note that participants were responders in the UG), but when it was their turn to make offers (DG), they refused to give such unfair offers to others. This pattern of deliberating longer on conflicting scenarios may relate to previous studies that reported that autistic children and adolescents tend to make utilitarian responses in sociomoral dilemmas, despite feeling more conflicted about their decision (Labusch et al., 2024). Taken together, our findings suggest that autistic children and adolescents may equally consider the emotional and rational implications of their decisions (Doebel, 2020).

Overall, the present experiment highlights the importance of including implicit measures (e.g. RTs) in decision-making tasks to understand the underlying cognitive processes in decision-making tasks with autistic individuals. However, the current study has several limitations. First, as in many autism studies, the sample size and participant characteristics may restrict the generalizability of the findings to the broader autistic spectrum. We believe this limitation was moderated by the strict inclusion criteria for our participants, which enhanced the homogeneity of the results. Second, while the UG and the DG are widely used to measure decision-making, incorporating alternative decision-making tasks featuring diverse cooperative and selfish scenarios can improve our understanding in this domain. For example, applying these tasks with real-person interactions may enhance the generalizability of the results to real-world interactions. Note, however, that studies with hypothetical and actual players have reported similar results (Acosta Ortiz, 2018; Dubois-Sage et al., 2024; Gillis & Hettler, 2007; Molins et al., 2024; Sally & Hill, 2006). Moreover, using hypothetical players provides the methodological advantage of experimental control by eliminating biases such as player reputation, trustworthiness, and personal characteristics, which can influence decision-making (Marchetti et al., 2019; Shang & Liu, 2022). In addition, participants played only one role in each game and the order of the games was not randomized; thus, some of the decisions could have been partially influenced by interpersonal strategies. However, the tasks were purposely designed to be brief to prevent changing strategies and to maintain a simple design that could sustain the attention of children and adolescents. We should also note that, although the BRIEF questionnaire is a valid instrument used to assess EFs (Garon et al., 2016; Tschida & Yerys, 2021), its measurements are subjective to the perception of parents or caregivers. It would be desirable, in future research, to add task-based measurement of EFs (see Mareva et al., 2024) and electrophysiological assessments (e.g. electroencephalogram (EEG)), which may provide greater depth in understanding the role of EF profiles associated with decision-making in autistic individuals (see Hoofs et al., 2018; Magnuson et al., 2019; Sokhadze et al., 2022). Furthermore, applying the present tasks in real-life settings and EEG measurements can increase our comprehension of how autistic individuals engage in decision-making within interactive contexts. Finally, since historically there have been fewer diagnoses of autism in females, leading to an imbalance in research representation, future studies could include more females to better understand decision-making and improve support and services for all individuals (see Lockwood Estrin et al., 2021).

In conclusion, the present study revealed that autistic participants were less inclined to propose selfish offers in the DG than non-autistic peers, a behavior positively correlated with better organizational skills. Furthermore, autistic participants took longer to decide when they were the most benefited participants. While both autistic and non-autistic children and adolescents showed aversion to inequality when receiving unfair offers, autistic participants also demonstrated this aversion when counterparts experienced an unfair distribution. These findings indicate that autistic children and adolescents may engage in a more deliberative decision-making process, demonstrating strengths in sociomoral reasoning. Rather than concluding that autistic individuals inherently rely less on social heuristics, our results suggest that both intuitive and deliberative processes may be used contextually, especially in selfless scenarios. These findings have practical implications, supporting clinical perspectives that recognize and leverage autistic decision-making tendencies to navigate social scenarios with confidence and adaptability.

Acknowledgements

The authors would like to kindly thank all the autistic community, specially the participants, their parents, and the researchers that were involved in this study.

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Laura Campos: Formal analysis; Funding acquisition; Investigation; Writing—review & editing.
Juan A. Pérez: Conceptualization; Validation.
Ana García-Blanco: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Writing—original draft; Writing—review & editing.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by Carlos III Health Institute (Ministry of Science and Innovation) through the Miguel Servet CP21/00085, Río Hortega CM21/00049, Río Hortega CM20/00143, and PFIS FI19/00202 contracts, as part of the PI18/01352, PI21/00549, and PI24/01259 Projects, and co-financed by the European Regional Development Fund "A way to achieve Europe." In addition, this work has been supported by the Spanish Ministry of Science, Innovation and Universities through the project grants FPU20/02548, FPU18/01997, and PSI2017-862120-P, and by the Department of Innovation, Universities, Science, and Digital Society of the Valencian Government (CIAICO/2021/172).

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Supplemental material

Supplemental material for this article is available online.

Note

1. In this study, the terms "selfish" and "selfless" are used solely to describe behaviors observed within the context of economic decision-making tasks and are not intended to

imply any judgment about a person's character. While previous studies have adopted these terms (e.g. Miraghaie et al., 2022), these behaviors do not necessarily translate to actions in complex, real-world social interactions. These terms are used to classify specific actions in controlled settings and do not reflect participants' personal traits.

References

Achenbach, T. M., & Edelbrock, C. (1991). Child behavior checklist. *Burlington (vt)*, *7*, 371–392.

Acosta Ortiz, A. M. (2018). *Other-regarding preferences and the decision behaviour of autistic people in the Ultimatum Game* [Doctoral thesis, City, University of London]. http://openaccess.city.ac.uk/

Alós-Ferrer, C., Garagnani, M., & Hügelschäfer, S. (2016). Cognitive reflection, decision biases, and response times. *Frontiers in Psychology*, *7*, 1–21. https://doi.org/10.3389/fpsyg.2016.01402

Apperly, I. A., & Butterfill, S. A. (2009). Do humans have two systems to track beliefs and belief-like states? *Psychological Review*, *116*(4), 953–970. https://doi.org/10.1037/a0016923

Azmat, F. (2020). Social exclusion and social inclusion. In W. Leal Filho, A. Azul, L. Brandli, A. Lange Salvia, P. Özuyar, & T. Wall (Eds.), *No poverty. Encyclopedia of the UN sustainable development goals* (pp. 1–10). Springer. https://doi.org/10.1007/978-3-319-69625-6_50-1

Baron-Cohen, S. (2000). Theory of mind and autism: A review. *International Review of Research in Mental Retardation*, *23*, 169–184. https://doi.org/10.1016/S0074-7750(00)80010-5

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind" ? *Cognition*, *21*(1), 37–46. https://doi.org/10.1016/0010-0277(85)90022-8

Belmonte Maldonado, M. J., González Marqués, J., Arias Martínez, R., & Fournier del Castillo, C. (2016). *Adaptación del BRIEF ("Behavior Rating Inventory of Executive Function") a población española y su utilidad para el diagnóstico del trastorno por déficit de atención* [Universidad Complutense de Madrid]. https://eprints.ucm.es/id/eprint/37563/

Brosnan, M., Lewton, M., & Ashwin, C. (2016). Reasoning on the autism spectrum: A dual process theory account. *Journal of Autism and Developmental Disorders*, *46*(6), 2115–2125. https://doi.org/10.1007/S10803-016-2742-4

Carlson, S. M., Zelazo, P. D., & Faja, S. (2013). Executive function. In P. D. Zelazo (Ed.), *The Oxford handbook of developmental psychology* (pp. 705–743). Oxford University Press. https://doi.org/10.1093/OXFORDHB/9780199958450.013.0025

Chamberlain, S. R., Aslan, B., Quinn, A., Anilkumar, A., Robinson, J., Grant, J. E., & Sinclair, J. (2023). Autism and gambling: A systematic review, focusing on neurocognition. *Neuroscience & Biobehavioral Reviews*, *147*, 105071. https://doi.org/10.1016/J.NEUBIOREV.2023.105071

Chen, M., Zhu, X., Zhang, J., Ma, G., & Wu, Y. (2021). Neural correlates of proposers' fairness perception in punishment and non-punishment economic games. *Current Psychology*, *40*(4), 1838–1849. https://doi.org/10.1007/s12144-019-0129-3

Cohen, J. (2013). Statistical power analysis for the behavioral sciences. In *Statistical power analysis for the behavioral sciences*. Routledge. https://doi.org/10.4324/9780203771587

Demetriou, E. A., DeMayo, M. M., & Guastella, A. J. (2019). Executive function in autism spectrum disorder: History, theoretical models, empirical findings, and potential as an endophenotype. *Frontiers in Psychiatry*, *10*, Article 753. https://doi.org/10.3389/fpsyt.2019.00753

Dempsey, E. E., Moore, C., Johnson, S. A., Stewart, S. H., & Smith, I. M. (2020). Morality in autism spectrum disorder: A systematic review. *Development and Psychopathology*, *32*(3), 1069–1085. https://doi.org/10.1017/S0954579419001160

Doebel, S. (2020). Rethinking executive function and its development. *Perspectives on Psychological Science*, *15*(4), 942–956. https://doi.org/10.1177/1745691620904771

Dubois-Sage, M., Lembert, Y., Jamet, F., & Baratgin, J. (2024). *Dictator game with a robot in children with autism spectrum disorders: Sharing is predicted by positive attributions towards the agent* (pp. 296–322). Springer. https://doi.org/10.1007/978-3-031-55245-8_20

Engel, C. (2011). Dictator games: A meta study. *Experimental Economics*, *14*(4), 583–610. https://doi.org/10.1007/S10683-011-9283-7/METRICS

Evans, J. S. B. T. (2010). Intuition and reasoning: A dual-process perspective. *Psychological Inquiry*, *21*(4), 313–326. https://doi.org/10.1080/1047840X.2010.521057

Evans, J. S. B. T. (2011). Dual-process theories of reasoning: Contemporary issues and developmental applications. *Developmental Review*, *31*(2–3), 86–102. https://doi.org/10.1016/J.DR.2011.07.007

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. https://doi.org/10.3758/BF03193146

Forgas, J. P., & Tan, H. B. (2013). To give or to keep? Affective influences on selfishness and fairness in computer-mediated interactions in the dictator game and the ultimatum game. *Computers in Human Behavior*, *29*(1), 64–74. https://doi.org/10.1016/J.CHB.2012.07.017

Forster, K. I., & Forster, J. C. (2003). DMDX: A Windows display program with millisecond accuracy. *Behavior Research Methods, Instruments, and Computers*, *35*(1), 116–124. https://doi.org/10.3758/BF03195503

García-Blanco, A., García-Blanco, M., del, C., Fernando, B., & Perea, M. (2016). Influence of computer feedback on attentional biases to emotional faces in children. *Computers in Human Behavior*, *64*, 881–887. https://doi.org/10.1016/j.chb.2016.07.064

Garon, N. M., Piccinin, C., & Smith, I. M. (2016). Does the BRIEF-P predict specific executive function components in preschoolers? *Applied Neuropsychology: Child*, *5*(2), 110–118. https://doi.org/10.1080/21622965.2014.1002923

Ghosn, F., Perea, M., Castelló, J., Vázquez, M. Á., Yáñez, N., Marcos, I., Sahuquillo, R., Vento, M., & García-Blanco, A. (2019). Attentional patterns to emotional faces versus scenes in children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *49*(4), 1484–1492. https://doi.org/10.1007/s10803-018-3847-8

Gillis, M. T., & Hettler, P. L. (2007). Hypothetical and real incentives in the ultimatum game and Andreoni's public goods aame: An experimental study. *Eastern Economic Journal*, *33*(4), 491–510. https://doi.org/10.1057/EEJ.2007.37

Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2010). *Child Neuropsychology TEST REVIEW Behavior Rating Inventory of Executive Function*. https://doi.org/10.1076/chin.6.3.235.3152

Güroğlu, B., van den Bos, W., Rombouts, S. A. R. B., & Crone, E. A. (2010). Unfair? It depends: Neural correlates of fairness in social context. *Social Cognitive and Affective Neuroscience*, *5*(4), 414–423. https://doi.org/10.1093/SCAN/NSQ013

Güth, W., Schmittberger, R., & Schwarze, B. (1982). An experimental analysis of ultimatum bargaining. *Journal of Economic Behavior & Organization*, *3*(4), 367–388. https://doi.org/10.1016/0167-2681(82)90011-7

Hartley, C., & Fisher, S. (2018). Do children with autism spectrum disorder share fairly and reciprocally? *Journal of Autism and Developmental Disorders*, *48*(8), 2714–2726. https://doi.org/10.1007/S10803-018-3528-7/TABLES/4

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

Hendrickson, N. K., & McCrimmon, A. W. (2019). Test review: Behavior Rating Inventory of Executive Function®, Second Edition (BRIEF®2) by Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. *Canadian Journal of School Psychology*, *34*(1), 73–78. https://doi.org/10.1177/0829573518797762

Hinterbuchinger, B., Kaltenboeck, A., Baumgartner, J. S., Mossaheb, N., & Friedrich, F. (2018). Do patients with different psychiatric disorders show altered social decision-making? A systematic review of ultimatum game experiments in clinical populations. *Cognitive neuropsychiatry*, *23*(3), 117–141. https://doi.org/10.1080/13546805.2018.1453791

Hoffman, E., McCabe, K., & Smith, V. (2008). Reciprocity in Ultimatum and Dictator Games: An introduction. *Handbook of Experimental Economics Results*, *1*(C), 411–416. https://doi.org/10.1016/S1574-0722(07)00046-7

Hoofs, V., Princen, M. M., Poljac, E., Stolk, A., & Poljac, E. (2018). Task switching in autism: An EEG study on intentions and actions. *Neuropsychologia*, *117*, 398–407. https://doi.org/10.1016/J.NEUROPSYCHOLOGIA.2018.07.008

Houser, D., & McCabe, K. (2014). Experimental economics and experimental game theory. *Neuroeconomics: Decision Making and the Brain: Second Edition*, 19–34. https://doi.org/10.1016/B978-0-12-416008-8.00002-4

Ikuse, D., Tani, M., Itahashi, T., Yamada, H., Ohta, H., Morita, T., Arai, G., Saga, N., Tokumasu, T., Ohta, M., Sato, A., & Iwanami, A. (2018). The effect of visual cues on performance in the ultimatum game in individuals with autism spectrum disorder. *Psychiatry Research*, *259*, 176–183. https://doi.org/10.1016/j.psychres.2017.10.013

Isler, O., Gächter, S., Maule, A. J., & Starmer, C. (2021). Contextualised strong reciprocity explains selfless cooperation despite selfish intuitions and weak social heuristics. *Scientific Reports*, *11*(1), 13868. https://doi.org/10.1038/s41598-021-93412-4

Jin, P., Wang, Y., Li, Y., Xiao, Y., Li, C., Qiu, N., Weng, J., Fang, H., & Ke, X. (2020). The fair decision-making of children and adolescents with high-functioning autism spectrum disorder from the perspective of dual-process theories. *BMC Psychiatry*, *20*(1), 1–11. https://doi.org/10.1186/S12888-020-02562-8/FIGURES/3

Jones, C., Simonoff, E., Baird, G., Pickles, A., Marsden, A. J. S., Tregay, J., Happé, F., & Charman, T. (2018). The association between theory of mind, executive function, and the symptoms of autism spectrum disorder. *Autism Research: Official Journal of the International Society for Autism Research*, *11*(1), 95–109. https://doi.org/10.1002/AUR.1873

Kaltwasser, L., Hildebrandt, A., Wilhelm, O., & Sommer, W. (2016). Behavioral and neuronal determinants of negative reciprocity in the ultimatum game. *Social Cognitive and Affective Neuroscience*, *11*(10), 1608–1617. https://doi.org/10.1093/SCAN/NSW069

Kaufman, A. and Kaufman N. (1990). Kaufman brief intelligence test. *Circle Pines (MN): American Guidance Service*.

Labusch, M., Perea, M., Sahuquillo-Leal, R., Bofill-Moscardó, I., Carrasco-Tornero, Á., Cañada-Pérez, A., & García-Blanco, A. (2024). Development of moral judgments in impersonal and personal dilemmas in autistic spectrum disorders from childhood to late adolescence. *Journal of Autism and Developmental Disorders*, *54*(2), 691–703. https://doi.org/10.1007/S10803-022-05795-6/FIGURES/5

Leder, J., & Schütz, A. (2018). Dictator Game. In *Encyclopedia of Personality and Individual Differences* (pp. 1–4). https://doi.org/10.1007/978-3-319-28099-8_652-1

Livingston, L. A., Shah, P., & Happé, F. (2019). Compensatory strategies below the behavioural surface in autism: A qualitative study. *The Lancet Psychiatry*, *6*(9), 766–777. https://doi.org/10.1016/S2215-0366(19)30224-X

Lockwood Estrin, G., Milner, V., Spain, D., Happé, F., & Colvert, E. (2021). Barriers to autism spectrum disorder diagnosis for young women and girls: A systematic review. *Review Journal of Autism and Developmental Disorders*, *8*(4), 454–470. https://doi.org/10.1007/s40489-020-00225-8

Magnuson, J. R., Peatfield, N. A., Fickling, S. D., Nunes, A. S., Christie, G., Vakorin, V., D'Arcy, R. C. N., Ribary, U., Iarocci, G., Moreno, S., & Doesburg, S. M. (2019). Electrophysiology of inhibitory control in the context of emotion processing in children with autism spectrum disorder. *Frontiers in Human Neuroscience*, *13*, Article 438639. https://doi.org/10.3389/FNHUM.2019.00078/BIBTEX

Marchetti, A., Baglio, F., Castelli, I., Griffanti, L., Nemni, R., Rossetto, F., Valle, A., Zanette, M., & Massaro, D. (2019). Social decision making in adolescents and young adults: Evidence from the Ultimatum Game and cognitive biases. *Psychological Reports*, *122*(1), 135–154. https://doi.org/10.1177/0033294118755673

Mareva, S., Lead Investigators, Astle, D., Baker, K., Gathercole, S., Holmes, J., Kievit, R., & Manly, T., Team of Researchers Akarca, D., Bathelt, J., Bettencourt, M., Bennett, M., Bignardi, G., Bishop, S., Bottacin, E., Bridge, L., Brkic, D., Bryant, A., . . . Zhang, M. (2024). Mapping neurodevelopmental diversity in executive function. *Cortex*, *172*, 204–221. https://doi.org/10.1016/J.CORTEX.2023.11.021

Miraghaie, A. M., Pouretemad, H., Villa, A. E. P., Mazaheri, M. A., Khosrowabadi, R., & Lintas, A. (2022). Electrophysiological markers of fairness and selfishness revealed by a combination of Dictator and Ultimatum Games. *Frontiers in Systems Neuroscience*, *16*, Article 765720. https://doi.org/10.3389/FNSYS.2022.765720/BIBTEX

Molins, F., Ben-Hassen Jemni, N., Garrote-Petisco, D., & Serrano, M. Á. (2024). Highly logical and non-emotional decisions in both risky and social contexts: Understanding decision making in autism spectrum disorder through computational modeling. *Cognitive Processing*, 1–10. https://doi.org/10.1007/s10339-024-01182-4

Nowak, M. A., Page, K. M., & Sigmund, K. (2000). Fairness versus reason in the Ultimatum Game. *Science*, *289*(5485), 1773–1775. https://doi.org/10.1126/SCIENCE.289.5485.1773

Paulus, M., & Rosal-Grifoll, B. (2017). Helping and sharing in preschool children with autism. *Experimental Brain Research*, *235*(7), 2081–2088. https://doi.org/10.1007/S00221-017-4947-Y/TABLES/1

Peirce, J., Gray, J. R., Simpson, S., MacAskill, M., Höchenberger, R., Sogo, H., Kastman, E., & Lindeløv, J. K. (2019). PsychoPy2: Experiments in behavior made easy. *Behavior Research Methods*, *51*(1), 195–203. https://doi.org/10.3758/S13428-018-01193-Y/FIGURES/3

Pérez-Lalama, K., Urrutia, M., Mancheno-Durán, S., Balseca-Bolaños, D., & Gamboa-Proaño, M. (2020). A quasi-experimental study on the decisions, behavioral regulation, and metacognition of Ecuadorian men. *Medwave*, *20*(3), Article e7855. https://doi.org/10.5867/MEDWAVE.2020.03.7855

Peterson, C. C., & Wellman, H. M. (2022). Altruism, hypocrisy and theory of mind in autistic and nonautistic children. *Developmental Psychology*, *58*(7), 1331–1344. https://doi.org/10.1037/DEV0000942

Polónyiová, K., Kruyt, J., & Ostatníková, D. (2024). To the roots of theory of mind deficits in autism spectrum disorder: A narrative review. *Review Journal of Autism and Developmental Disorders*, 1–5. https://doi.org/10.1007/S40489-024-00457-Y/METRICS

Rutter, M., Le Couteur, A., & Lord, C. (2003). *ADI-R: Autism diagnostic interview revised*. Los Angeles: Western Psychological Services.

Sally, D., & Hill, E. (2006). The development of interpersonal strategy: Autism, theory-of-mind, cooperation and fairness. *Journal of Economic Psychology*, *27*(1), 73–97. https://doi.org/10.1016/J.JOEP.2005.06.015

Sanfey, A. G. (2007). Social decision-making: insights from game theory and neuroscience. *Science*, *318*(5850), 598–602. https://doi.org/10.1126/science.1142996

Sanfey, A. G., Rilling, J. K., Aronson, J. A., Nystrom, L. E., & Cohen, J. D. (2003). The neural basis of economic decision-making in the Ultimatum Game. *New Series*, *300*(5626), 1755–1758.

Schmitz, E. A., Banerjee, R., Pouw, L. B., Stockmann, L., & Rieffe, C. (2015). Better to be equal? Challenges to equality for cognitively able children with autism spectrum disorders in a social decision game. *Autism*, *19*(2), 178–186. https://doi.org/10.1177/1362361313516547

Shang, J., & Liu, Z. (2022). Vocal attractiveness matters: Social preferences in cooperative behavior. *Frontiers in Psychology*, *13*, Article 877530. https://doi.org/10.3389/FPSYG.2022.877530/BIBTEX

Shiri, V., Hoseyni, S. A., Pishyareh, E., Nejati, V., Emami, M., & Shiri, E. (2018). Is there any correlation between executive dysfunction and behavioral symptoms in autistic children? A systematic review. *Archives of Neuroscience*, *5*(2), 64303. https://doi.org/10.5812/archneurosci.64303

Sodian, B., Schuwerk, T., & Kristen, S. (2015). Implicit and spontaneous theory of mind reasoning in autism spectrum disorders. In *Autism Spectrum Disorder—Recent Advances*. IntechOpen. https://doi.org/10.5772/59393

Sokhadze, E. M., Shaban, M., El-Baz, A. S., Tasman, A., Sears, L., & Casanova, M. F. (2022). Event-related potentials and gamma oscillations in EEG as functional diagnostic biomarkers and outcomes in autism spectrum disorder treatment research. In *Neural Engineering Techniques for Autism Spectrum Disorder: Volume 2: Diagnosis and Clinical Analysis* (Vol. 2, pp. 297–319). Academic Press. https://doi.org/10.1016/B978-0-12-824421-0.00022-9

Townsend, L., Robeson, A., Vonk, J., & Rohrbeck, K. (2021). Autism does not dictate children's lack of sharing in a prosocial choice test. *Journal of Autism and Developmental Disorders*, *51*(6), 2029–2035. https://doi.org/10.1007/S10803-020-04691-1/FIGURES/1

Tschida, J. E., & Yerys, B. E. (2021). Real-world executive functioning for autistic children in school and home settings. *Autism*, *26*(5), 1095–1107. https://doi.org/10.1177/13623613211041189

van der Plas, E., Mason, D., & Happé, F. (2023). Decision-making in autism: A narrative review. *Autism*, *27*(6), 1532–1546. https://doi.org/10.1177/13623613221148010

Van Dijk, E., & De Dreu, C. K. W. (2021). Experimental games and social decision making. *Annual Review of Psychology*, *72*, 415–438. https://doi.org/10.1146/ANNUREV-PSYCH-081420-110718

Wang, Y., Xiao, Y., Li, Y., Chu, K., Feng, M., Li, C., Qiu, N., Weng, J., & Ke, X. (2019). Exploring the relationship between fairness and "brain types" in children with high-functioning autism spectrum disorder. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *88*, 151–158. https://doi.org/10.1016/j.pnpbp.2018.07.008

Woodcock, K. A., Cheung, C., González Marx, D., & Mandy, W. (2020). Social decision making in autistic adolescents: The role of theory of mind, executive functioning and emotion regulation. *Journal of Autism and Developmental Disorders*, *50*(7), 2501–2512. https://doi.org/10.1007/s10803-019-03975-5

Zapparrata, N. M., Brooks, P. J., & Ober, T. M. (2023). Slower processing speed in autism spectrum disorder: A meta-analytic investigation of time-based tasks. *Journal of Autism and Developmental Disorders*, *53*(12), 4618–4640. https://doi.org/10.1007/S10803-022-05736-3

Zheng, Y., Yang, Z., Jin, C., Qi, Y., & Liu, X. (2017). The influence of emotion on fairness-related decision making: A critical review of theories and evidence. *Frontiers in Psychology*, *8*, 1592. https://doi.org/10.3389/FPSYG.2017.01592