Research in Autism Spectrum Disorders 26 (2016) 71–79

Contents lists available at ScienceDirect

Research in Autism Spectrum Disorders

journal homepage: http://ees.elsevier.com/RASD/default.asp

Reduced social coordination in Autism Spectrum Disorders

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ARTICLE INFO

Article history:
Received 7 September 2015
Received in revised form 28 February 2016
Accepted 9 March 2016
Available online 17 March 2016

Keywords:
Autism Spectrum Disorders
Coordination
Theory of Mind
Self-reference
Decision making

ABSTRACT

In the present study, we investigated whether individuals with Autism Spectrum Disorders (ASD) were able to coordinate with an unknown partner on the same outcome using a two-person pure coordination game. Twenty-one adults with ASD and twenty-one typically developed (TD) control participants were presented with sets of four items, and were asked to choose one of these items under three conditions: picking one's own personal preferred item, guessing what might be the partner's preference, and choosing an item in order to coordinate with the partner's choice. Each set included a salient item that stood out for its distinctive properties, known as the *focal point*. The results showed that individuals with ASD choose more often their preferred items than the salient cues to coordinate with others and to guess the partner's preference, as compared to TD controls. Performance for coordination was related to clinical scores assessing difficulties in communication and the severity of the autistic traits, but was unrelated to verbal intelligence and verbally mediated Theory-of-Mind task. These findings suggest that self-bias processes in decision-making might be a source of impairment in social coordination and interaction in ASD.

1. Introduction

Successful social interactions often require that social partners coordinate their behavior despite minimal communication. Impairments in social interaction and communication are core features of Autism Spectrum Disorders (ASDs) (DSM-V, American Psychiatric Association; ICD-10, World Health Organization). Social difficulties in individuals with ASD have generally been investigated using Theory of Mind (ToM) tasks, which assess the ability to attribute mental states, such as intentions, beliefs, and desires, to oneself and to others (Baron-Cohen, Leslie, & Frith, 1985; Leslie 1987). Adults with ASD are usually able to pass first- and second-order ToM tasks (Bowler, 1992), but they encounter greater difficulties when tested with more advanced ToM tasks, such as those of the *Strange Stories* (Happé, 1994) and the *Faux Pas* (Zalla, Stopin, Ahade, & Leboyer, 2009), or in situations requiring spontaneous mentalizing abilities (e.g., Senju, Southgate, White, & Frith, 2009). While the ToM hypothesis is of considerable interest in explaining social impairments in ASD, in most tasks used to

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http://dx.doi.org/10.1016/j.rasd.2016.03.007
1750-9467/

investigate social abilities, participants are passive observers of social scenarios, and do not play an active role in the experimental situation.

Recently, the game-theoretic framework has provided novel tools for studying how individuals make decisions in meaningful social interaction (King-Casas, & Chiu, 2012). Social exchanges often result from coordination between two or more people trying to achieve a common goal despite minimal communication. For example, if two friends get lost separately in a multiplex hotel before they have checked into a common room, it is likely that they would converge on the same outcome: that the reception desk is the location to which they have to come back to regain contact and coordinate. The basic features of this kind of interaction are modeled in pure coordination games. Formally, the solutions for these kinds of games cannot be obtained by adopting an optimal single strategy based on the mathematical structure of the game (Dixit, Skeath, & Reiley, 2009). Empirical results in economic behavioral studies have demonstrated that the solution of a coordination game relies on the recognition of *focal points*, i.e., items that are more salient than others for a matter of "conventional, cultural or psychological priority" (Bardsley, Mehta, Starmer, & Sugden, 2010; Mehta, Starmer, & Sugden, 1994; Schelling, 1960). The use of *focal points* does not require the making of inferences about other individuals' choices or preferences, it rather consists in the recognition of conventional items, which stand out for their distinctive, categorical, and stereotypical properties, that is, for their uniqueness. The search for such objective criteria, requiring the setting aside of one's personal preferences or monetary incentives, would likely rely on a set of preserved cognitive abilities for coordination.

When facing coordination tasks, people could recognise that there is no valid logical solution, and give responses based on features that spontaneously come to mind, essentially based on personal preferences. This is referred as *primary salience* (Mehta et al., 1994). In psychological terms, this kind of behavior would be driven by choices based on self-relevance. Alternatively, to guide their choice people might employ *secondary salience*. In that case, each partner would choose the item that he/she believes to have primary salience for the other. Thus, participants should construct a representation of the partner's response and possibly inhibit processes linked to their own primary salience. Decisions based on secondary salience would likely depend on ToM abilities and/or self-other perspective-taking.

Here, we argue that the selection of socially salient features on which partners might coordinate, regardless of their respective personal preferences, requires the metacognitive capacities to represent other minds as different from one's own mind and to form the shared intention to converge on the same solution. In line with the "theory-theory" (Gopnik, & Wellman, 1992), in order to make sense of other minds, that is to appreciate when others are in different situations or in possession of different knowledge and mental states, one has to learn and apply a general ToM. Conversely, according to the "simulation theory" view (Goldman, 1992; Gordon, 1992), people use themselves as a source model, predicting others' thoughts and feelings by imagining themselves in the other person's situation. While both theory–theory and simulation mechanisms may play a role in understanding others, it is likely that by adulthood, an individual's attempts at perspective-taking in everyday life often result from the integration of these two types of cognitive processes.

In the present study, we investigated coordination abilities in adults with ASD and in typically developed volunteers using a modified two-person coordination game (Bardsley et al., 2010). Participants were asked to select one label in three experimental conditions. In the picking condition, they had to choose one of four presented labels on the basis of their own preference. In the guessing condition, they had to choose the label corresponding to the partner's putative preference. In the coordination condition, they had to choose a label (the *focal point*) in order to coordinate with the partner's choice. Each set included one label, the *focal point*, whose salience was determined by the *odd-one-out rule – i.e., exclusion of the item that does not belong to a set of stimuli that share a common feature* – (Bardsley et al., 2010; Mehta et al., 1994). The labels in each set correspond to items of the same semantic category, but only one label has a distinctive or salient feature and can be used as a *focal point*. For instance, in the set composed of "diamond", "emerald", "glass", and "sapphire", "glass" works as the focal point since this is the only non-precious stone within the set. We expected participants with ASD to show diminished abilities to coordinate with a partner, as indexed by their difficulties with choosing the focal points in the coordination condition. Furthermore, we examined whether their performance was affected by difficulties in ToM, as measured by the Faux Pas test (Baron-Cohen, O'Riordan, Stone, Jones, & Plaisted, 1999; Zalla et al., 2009) and by the severity of the autistic symptomatology, as assessed by the Autism Spectrum Quotient (Baron-Cohen et al., 2001) and the Autism Diagnostic Interview–Revised (ADI-R) (Lord, Rutter, & Le Couteur, 1994) in the areas of reciprocal social interaction and communication. Importantly, ToM impairments in individuals with ASDs might imply not only failure to understand that others have minds and that behaviour is determined by mental states, but also that other minds have thoughts, desires and preferences different from theirs.

Due to the verbal nature of the task, to rule out the possibility that performance in coordination would be affected by diminished abstract reasoning and verbal intelligence, participants were administered a semantic categorization test, prior to the experiment, and experimental variables were correlated with the verbal subscale score of the Wechsler Adult Intelligence Scale (WAIS-III, Wechsler, 1997). We predicted that difficulties in coordination would be related to a deficit in ToM and/or the self-other distinction, leading participants with ASD to use more often their own preferred items, based on primary salience, to coordinate with a partner.

Table 1
Means (±standard deviations) of demographic and clinical data for ASD and TD participants. The range for each variable is reported in square brackets.

	ASD (N = 21)	TD (N = 21)
Age	35.43 ± 14.46 [20–70]	31.43 ± 13.57 [19–60]
Education	13.95 ± 3.8 [8–18]	13.76 ± 2.0 [20–70]
Full-scale IQ	101.71 ± 18.81 [70–128]	102.76 ± 14.32 [84–130]
Verbal IQ	104.86 ± 17.32 [71–128]	102.48 ± 17.84 [81–142]
Performance IQ	100.65 ± 17.59 [70–120]	102.9 ± 11.89 [84–137]
ADI [B,C,D][a]	18.53 ± 5.4; 11.41 ± 5.87; 4.81 ± 2.51 [10–28] [1–22] [1–11]	–
Autism Spectrum Quotient	37.52 ± 6.45 [26–47]	18.86 ± 8.11 [6–35]
Faux Pas total score[b]	36.84 ± 14.23 [0–54]	47.37 ± 5.59 [40–58]

[B] = reciprocal social interaction, [C] = communication, [D] = stereotyped behaviors.
[a] Data from 4 ASD participants were missing.
[b] Data from 2 ASD and 2 TD participants were missing.

2. Material and methods

2.1. Participants

Twenty-one male adults (age 35.43 ± 14.46 years) with a clinical diagnosis of ASD according to DSM-IV R (American Psychiatric Association, 1994), the ADOS (Lord et al., 2000), and ASDI (Asperger Syndrome Diagnostic Interview, Gillberg, Råstam, & Wentz, 2001), were recruited from Albert Chenevier Hospital in Créteil (see Table 1 for details). The inclusion criteria for the sample were based on retrospective parental information about the early language development of their child. All diagnoses were made by experienced clinicians and were based on clinical observations of the participants.

A semi-structured interview with parents or caregivers using the ADI-R (Autism Diagnostic Interview, Lord et al., 1994) yielded scores in three content areas: [B] social interaction, [C] communication, and [D] repetitive and stereotyped behaviors. The cut-off points for these domains are 10, 8, and 3, respectively. All participants scored above the cut-off. Twenty-one typically developed (TD) control male participants (age 31.43 ± 13.57) were recruited from the community as volunteers to match the distribution of the clinical group with respect to age, education, IQ and gender (see Table 1 for details). TD participants were screened by expert clinicians to exclude anyone with a history of psychiatric or neurological disorders. All participants were native French speakers, and had normal/corrected to normal vision.

All participants completed the WAIS-R (WAIS-III, Wechsler, 1997) providing measures of verbal, performance, and full-scale IQ and the Autism Spectrum Quotient (AQ), a self-report questionnaire for measuring autistic-like traits in the population at large (scores higher than 30 on the AQ indicates significant levels of autistic traits). Mentalizing abilities were assessed with an advanced ToM task, the Faux-pas Recognition Test (Baron-Cohen et al., 1999; Zalla et al., 2009).

Overall, individuals with ASD did not differ from the TD participants in chronological age, $t(40) = 0.92$, $p > 0.3$, education, $t(40) = 0.2$, $p > 0.8$, or IQ-level (Full-scale, $t(40) = -0.2$, $p > 0.8$; Verbal, $t(40) = 0.44$, $p > 0.6$, and Performance, $t(39) = -48$, $p > 0.6$). Participants with ASD scored significantly higher in Autistic Spectrum Quotient, $t(40) = 8.26$, $p < 0.001$, $d = 2.61$, and performed significantly lower on Faux Pas Recognition, $t(36) = -3$, $p < 0.005$, $d = 1$, as compared to TD participants.

The present research study was conducted according to the principles expressed in the Declaration of Helsinki, and it has been approved by the local Ethical committee (Inserm, C07-33). All participants signed an informed consent agreement before taking part in the study.

2.2. Stimuli and procedure

Participants sat in front of a computer screen located approximately 50 cm away. They were informed at the beginning of the experiment that they had to play with a partner in a computer game, but that they were not allowed to talk and communicate with her/him. A black wooden frame was interposed between the two players so that they could not see each other and communicate at any moment while entering the room or during the whole test session. Each participant with ADS was paired with a TD participant. Subjects were not informed about their partner's identity and/or clinical profile and no feedback was given about the other person's responses throughout the study.

Stimuli consisted of twenty sets of four words. In each set the four items belonged to the same semantic category; for each set only one item, i.e., the 'focal point', had a distinctive or salient characteristic[1] (See Appendix A for the full list of items).

Each set was presented on a computer screen and remained on the screen until the participant's response. Responses were recorded by means of a key press on an optical mouse. The same 20 sets of items were presented in blocks in three

[1] Items in each set were chosen considering the list of English words of the Bardsley study, previously validated in a French sample. We presented sets of translated words to 50 French participants and asked them to indicate for each set what item would be salient, i.e., would stick out for its conventional and cultural priority. Except for the 'intruder', the members of each of the 20 sets of 4 words selected for the study were classified as belonging to the same category.

experimental conditions. In the *coordination* condition, participants were instructed to attempt to choose the same item as the partner. In the *picking* condition they were asked to choose the item they preferred. In the *guessing* condition they were asked to choose the item they believed the partner would prefer. The order of block presentation and of the members of each set of items in each block were counter-balanced between subjects. Participants were informed of the upcoming condition by instructions on the screen (See Appendix B for samples of instructions for the three experimental conditions: coordination, picking, guessing).

Prior to the experiment, participants were presented with a categorization task to evaluate their abilities in semantic categorization. Fifteen sets of four labels of the main experiment were presented in the categorization task. Each set included two additional labels. Participants were asked to indicate which of the two additional items was semantically compatible with the current set of four labels (See Appendix C).

2.3. Statistical analysis

The number of choices of the focal point (focal point responses) was taken as dependent measure and submitted to a 2 group (ASD, TD) × 3 condition (coordination, guessing, picking) mixed ANOVA. Partial Eta-squared (η_p^2) was used as a measure of effect size in ANOVA. Two samples *t*-tests were run on the number of picking responses that were given in the coordination condition (*Self-bias responses*), and on the number of picking responses that were given in the guess condition (*Self-other distinction score*). Effect sizes were calculated to determine the magnitude of the difference between the two groups using Cohen's *d* (Cohen, 1988). Correlations between measures were calculated based on Pearson's correlation coefficients.

3. Results

3.1. Categorization task

Participants with ASD and TD controls did not differ in their error rate (1.24 ± 0.3 and 1.57 ± 0.24, respectively) $t(40) = -0.86$, $p > 0.3$.

3.2. Choice of focal point

The ANOVA yielded a main effect of condition, $F(2, 80) = 27.88$, $p < 0.001$, $\eta_p^2 = 0.41$. Post-hoc (LSD) comparisons revealed that participants provided more focal point responses in the coordination condition compared to both the guessing ($p < 0.001$) and picking ($p < 0.001$) conditions. The main effect of group was not significant, $F < 1$. Critically, the interaction between group and condition was significant, $F(2, 80) = 4.93$, $p < 0.01$, $\eta_p^2 = 0.11$. Post-hoc (LSD) comparisons revealed that the interaction was due to the fact that while the two groups chose the focal point with the same probability in the picking ($p > 0.05$, $d = 0.17$) and guessing conditions ($p > 0.05$, $d = 0.82$), in the coordination condition individuals with ASD provided fewer focal point responses, as compared to TD controls ($p < 0.01$, $d = 0.61$), (Fig. 1).

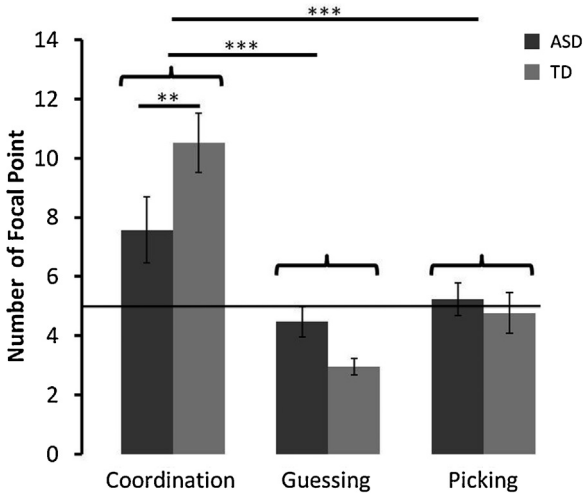

Fig. 1. Mean focal responses of participants with ASD (dark grey) and TD (light gray) controls as a function of the coordination, guessing, and picking conditions. Error bars represent standard error means (SEM). $^{**}p < 0.01$, $^{***}p < 0.001$. The black horizontal line, corresponding to 5, indicates the chance level of choosing the focal point.

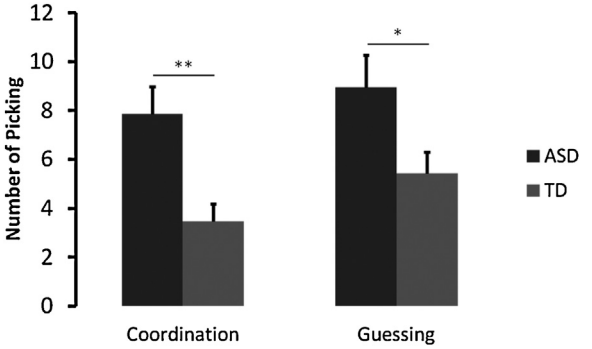

Fig. 2. Mean picking responses of participants with ASD (dark grey) and TD controls (light gray) as a function of the coordination and guessing conditions. Error bars represent standard error means (SEM). $^{**}p < 0.01$, $^{***}p < 0.001$.

To further characterize this interaction, we ran two separate within-group one-way repeated measures ANOVAs. These analyses yielded a significant main effect of condition in both the ASD, $F(2, 40) = 4.97$, $p < 0.05$, $\eta_p^2 = 0.2$, and TD, $F(2, 40) = 26.58$, $p < 0.001$, $\eta_p^2 = 0.57$, groups. Post-hoc (LSD) comparisons revealed that ASD participants chose more often the focal point in the coordination, compared to the picking ($p < 0.05$) and guessing ($p < 0.01$) conditions. Similarly, the TD group chose more often the focal point in the coordination than in the picking and guessing conditions (both $p < 0.001$).

3.3. Self-bias and the self-other distinction

To determine whether the reduced coordination observed in participants with ASD was due to a self-bias, we compared responses in the coordination condition based on the subjects' personal preferences (picking). The analysis revealed that participants with ASD chose more often their own preferred item in the coordination condition, as compared to TD participants (7.86 ± 1.13 vs. 3.48 ± 0.7, respectively), $t(40) = 3.31$, $p < 0.01$, $d = 1.05$ (Fig. 2).

Moreover, to determine the effect of a self-bias on the inferencing of the partner's preference, we compared responses in the guessing condition based on a participant's personal preferences (picking). This analysis revealed that participants with ASD chose more often their own preferred item in the guessing condition, as compared to the TD group (8.95 ± 1.31 vs. 5.43 ± 0.88, respectively), $t(40) = 2.23$, $p < 0.05$, $d = 0.71$ (Fig. 2).

3.4. Correlation analyses

We ran correlation analyses between the experimental variables, i.e., the number of focal point responses, and the self-bias score in the coordination condition, the verbal IQ, the AQ, the Faux Pas total scores, and the sub-scores of the Autism Diagnostic Interview-Revised (ADI-R; Lord et al., 1994) measuring difficulties in the domains of social interaction and communication (verbal and non-verbal).

We found that the number of focal point responses in the coordination condition correlated negatively with the self-bias score ($r = -0.66$, $p < 0.01$). Moreover, the number of focal point responses correlated negatively with the communication sub-score of the ADI-R ($r = -0.47$, $p < 0.05$) in participants with ASD, and the AQ score in both groups (ASD: $r = -0.47$, $p < 0.05$; TD:

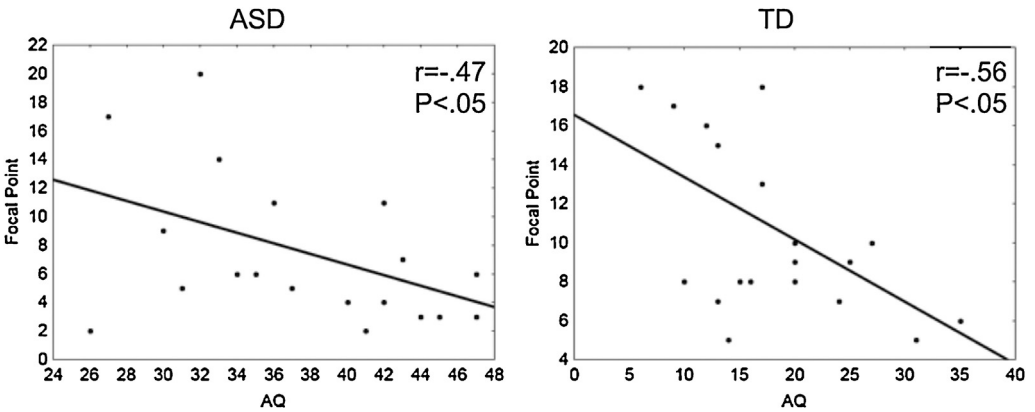

Fig. 3. Correlations between focal point responses in the coordination condition and the autistic spectrum quotient (AQ) score in participants with ASD (left) and TD controls (right).

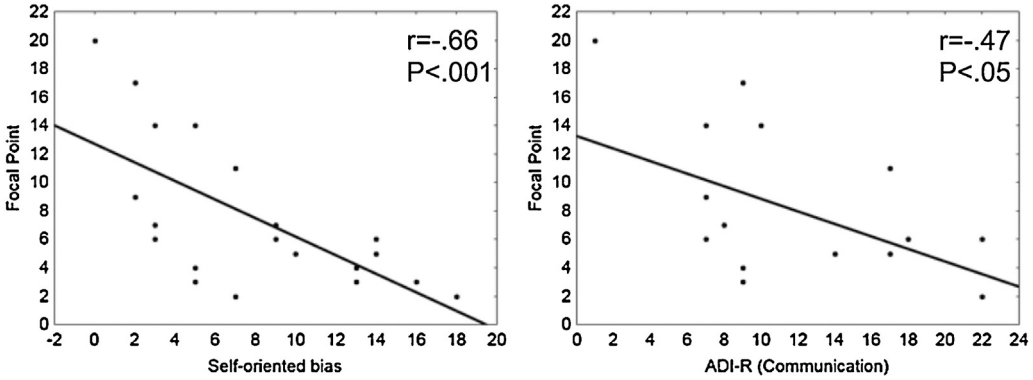

Fig. 4. Correlations between focal point responses in the coordination condition and the self-oriented score (left), and the ADI-com sub-score (right) in participants with ASD.

$r = -0.56, p < 0.05$) (see Figs. 3 and 4). The correlations between the verbal IQ and the sub-scores of reciprocal social interaction, as well as the verbal IQ and the Faux Pas score were not significant (see Table 2). We ran partial correlations between the variables showing an association with coordination performances and clinical scores, while controlling for verbal IQ. The correlations between the number of focal point responses in the coordination condition and the AQ score ($r = -0.47, p < 0.05$), the communication sub-score of the ADI-R ($r = -0.52$, $p < 0.05$), and the self-bias score ($r = -0.65$, $p < 0.01$) remained significant.

4. Discussion

In the current study we investigated whether individuals with ASD were able to engage in a coordinative activity tacitly, i.e., with no possibility of exchanging information. In so doing, we asked pairs of ASD and TD participants to play a pure coordination game in which they were presented with twenty sets of four items with the items of each set belonging to a single semantic category. They were required to express their own preference (*picking*), to infer the partner's preference (*guessing*), and to choose one item, the so-called *focal point*, that would enable players to converge on the same solution (*coordination*).

The present results indicate that participants with ASD chose the *focal point* items less frequently in the coordination condition, and were more likely to select items based on their personal preference (i.e., primary salience), in both the coordination and guessing conditions, as compared to the TD participants group. Interestingly, coordination performance, as indexed by the number of focal point items selected, significantly correlated with the number of self-oriented responses, confirming that the enhancement of a self-bias in social decision-making and difficulties in coordinating with others are strongly related in ASD.

These findings strongly suggest that difficulties in coordinating with others in individuals with ASD might be due to self-bias processes in social decision making. As previously demonstrated in studies with typically developed adults (Schelling, 1960; Sugden, 1995), the solution of a pure coordination game relies on the recognition of "prominent" or "salient" features that, when available, stand out from others with respect to conventional, cultural, and stereotypical properties, and enable players to converge on the same solution. In addition, in our study, coordination performance correlated negatively with difficulties in (verbal and non-verbal) communication, as assessed by the Autism Diagnostic Interview-Revised (ADI-R; Lord et al., 1994) in ASD participants, and with the AQ total score in both groups. Importantly, these correlations remained significant when controlling for verbal IQ. This suggests that diminished performance in coordination is related to the severity of the autistic traits and could be considered as a hallmark feature of the broad autism phenotype. Moreover, it is noteworthy that diminished coordination abilities in our participants with ASD could not be explained by difficulties with

Table 2
Correlations (r and p values) between the number of focal points selected in the coordination condition and self bias response, and clinical variables for ASD and TD participants.

	Number of focal points	
	ASD	TD
Self-bias responses	−0.66; $p < 0.01$	−0.43; $p > 0.05$
Faux Pas total score	0.38; $p > 0.1$	0.23; $p > 0.1$
Autism Spectrum Quotient	−0.47; $p < 0.05$	−0.56; $p < 0.01$
ADI-R B (reciprocal social interaction)	−0.13; $p > 0.1$	–
ADI-R C (communication)	−0.47; $p < 0.05$	–
Verbal IQ	0.32; $p > 0.1$	−0.04; $p > 0.1$

abstract reasoning and categorisation (e.g., Minshew, Meyer, & Goldstein, 2002), as the two groups performed equally well in the semantic categorization task, nor could they be explained by reduced verbal abilities, since coordination performance (i.e., the number of focal point responses) did not correlate with verbal IQ. However, the significant correlation between coordination performance and the communication sub-score of the ADI-R suggests that impairments in coordination and communication might be strictly related in ASD.

Abnormal language abilities and difficulties in communication are core features of the autistic cognitive and clinical phenotype. Indeed, a large body of literature has shown that language impairments in ASD mainly concern the domain of pragmatics (e.g., Frith, 1989), as documented by studies showing that individuals with ASD experience difficulties in mastering conversational turn-taking, showing poor coordination with their interlocutors and reduced ability for sustained attention and attunement to a conversational sequence (for a review see Groen, Zwiers, van der Gaag, & Buitelaar, 2008).

Although, in the present study, participants with ASD performed poorly on the *Faux Pas* task, we did not find a significant correlation between ToM abilities and the number of *focal points* selected in the coordination condition. Contrary to our prediction, this finding suggests that explicit and verbally mediated ToM abilities are not at stake in this kind of coordination game. Previous studies using experimental economic games (i.e., ultimatum and dictator games) for children with ASD (Hill, Sally, & Frith, 2004; Sally and Hill, 2006) have suggested that ToM abilities are not necessary to perform cooperative games successfully (Hill et al., 2004; Sally & Hill, 2006). Nevertheless, the economic games used in these earlier studies and the pure coordination game employed here differs in many relevant ways, since no communication and no economic incentive were present in our task.

The present findings are in accordance with previous evidence showing behavioural and neuronal abnormalities in individuals with ASD during tasks requiring the distinction between self and others and in perspective taking (for a review see Lombardo & Baron-Cohen, 2011), likely due to an enhanced propensity to simulate the mind and behaviour of others by adopting their own perspective (Dawson & Ferland, 1987). Lombardo and Baron-Cohen (2010) argued that individuals with ASD have difficulties understanding the dual nature of the self, i.e., that one is, in a context-dependent way, at the same time similar to, yet different from others.

Although ToM remains a valid theoretical framework, the nature of the cognitive processes involved in social coordination is still a matter of debate. While some studies have pointed to the predominant role of the strategic processes in tasks assessing coordination abilities (McMillan, Rascovsky, Khella, Clark, & Grossman, 2011; Yoshida, Seymour, Friston, & Dolan, 2010), Kuo, Sjöström, Chen, Wang, and Huang (2009) have provided evidence for the concomitant role of intuitive thinking, based on fast, effortless and emotional processes, in a pure coordination game. Spontaneous and intuitive heuristic processes enable humans to react quickly in complex and uncertain situations, such as social interaction (Allman, Watson, Tetreault, & Hakeem, 2005). Fast decisions are often required in an unfolding, rapidly changing context, and the need for intuitive thinking could be even more crucial in conditions in which people have to coordinate their actions with a limited, or absent, possibility of communicating, as in the present task. As Levin et al. (2015) have reported, participants with ASD are less able to engage in intuitive thinking, while they show preserved rule-following abilities. It is thus possible that impairment in automatic and intuitive mindreading processes could impact the learning of efficient heuristic rules supporting coordinated solutions. In line with these previous findings, it is likely that, in our participants with ASD, difficulties in representing others' desires as different from their own, would reflect the prominent effect of self-biased processes and the reduced automaticity exerted by social stereotype information in rapid communication and on-line social interaction (Zalla et al., 2014).

According to Epley, Keysar, Van Boven, and Gilovich (2004), perspective taking involves a multistage process requiring extra time and cognitive resources. These authors propose that people initially *anchor* on their own perspective, presumably because it is often easily accessible, and subsequently *adjust* to account for differences between their own and others' minds. The authors show that hindering a subject's ability to expend attentional resources, or subjecting performance to time pressure systematically produces more egocentric judgments. Therefore, although our participants were asked to provide responses with no time limit, reduced perspective-taking and self-biased judgements in participants with ASD might result from diminished cognitive flexibility and set-switching abilities. In attempting to achieve actual coordination with an unknown partner, individuals with ASD might be inclined to opt for self-referential processes that bias the selection towards their own preferences rather than engaging in more effortful cognitive computations on another's mental states and attitudes. However, it should be noted that although participants with ASD did indeed choose the focal point less frequently, their choice of focal point in the coordination condition was above chance level. Moreover, they chose the focal point more often in the coordination condition than in the other two conditions. This result suggests reduced, but not absent, coordination abilities, and these abilities could be exploited to promote remediation strategies that target these functions.

Finally, we should address a few limitations on the present study. The first concern is that we included only male participants. Even if we did not have any hypothesis on gender effect in our task, this certainly limits the generalization of our results to the broader ASD population. As revealed by previous research in TD individuals using economic games, women exhibit more reciprocity than men (Croson, & Buchan, 1999) while men interact more strategically (Buchan, Croson, & Solnick, 2008) suggesting gender differences in coordination abilities.

The second limitation concerns the ecological validity of the task. Although our paradigm is more proactive than classical social cognition tasks, it was designed to simulate a pure coordination game in the absence of communication. Hence, the experimental setup remains different from those ecological situations in which social exchanges are verbally mediated and

the agents are able to mutually influence each other's behaviour and update information about their partner during the interaction.

In conclusion, the present findings reveal that difficulties in coordination in individuals with ASD might be due to a self-bias effect on social decision-making. Our findings support the view that coordination might crucially rely on the ability to intuitively identify socially salient features and to use them as coordination tools, even in the absence of communication and explicit agreements on conventional hints. Such difficulties in our participants with ASD did not depend on impairment in explicit, verbally mediated ToM abilities and on verbal intelligence, but appear to be related to their difficulties in communication, and to the severity of the autistic symptomatology, as measured by clinical scales. Further research investigating the specific cognitive processes involved in coordination using more socially interactive paradigms will hopefully improve our understanding of impairments of social decision-making and interaction in ASD. Future work is also warranted to clarify how gender impacts social abilities in individuals with ASD.

Acknowledgments

We gratefully acknowledge the commitment of the participants and their families to the pursuit of our research on autism. This research was supported by Fondation FondaMental and Fondation de France to TZ, GG, and ML.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.rasd.2016.03.007.

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