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ORIGINAL PAPER

Selective Pragmatic Impairment in Autism Spectrum Disorder: Indirect Requests Versus Irony

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Abstract
Autism Spectrum Disorder (ASD) is often described as being characterised by a uniform pragmatic impairment. However, recent evidence suggests that some areas of pragmatic functioning are preserved. This study seeks to determine to which extent context-based derivation of non-linguistically encoded meaning is functional in ASD. We compare the performance of 24 adults with ASD, and matched neuro-typical adults in two act-out pragmatic tasks. The first task examines generation of indirect request interpretations, and the second the comprehension of irony. Intact contextual comprehension of indirect requests contrasts with marked difficulties in understanding irony. These results suggest that preserved pragmatics in ASD is limited to egocentric processing of context, which does not rely on assumptions about the speaker's mental states.

Keywords Autism · Pragmatics · Communication · Irony · Indirect speech acts · Request · Eye-tracking · Executive function · Social motivation

A Uniform Pragmatic Impairment?

Language profiles in Autism Spectrum Disorder (ASD) are characterised by tremendous heterogeneity, with structural linguistic skills ranging from fully functional to inexistent. Difficulties at the level of language use with its *pragmatic* aspects, however, are known to be a robust hallmark of ASD, independently of linguistic and cognitive development. Impaired pragmatic skills may cause difficulties in taking part in verbal exchanges, even in adolescents and adults with ASD whose linguistic and cognitive abilities are otherwise unimpaired (e.g., de Villiers et al. 2006; Paul et al. 2008). On the comprehension end, difficulties are often reported when the communicated content departs from the literal linguistic meaning (e.g., Attwood 2015). To give a non-exhaustive list, children and adults with ASD have been said to experience difficulties in comprehending metaphors, conversational inferences, indirect speech acts, jokes and irony (e.g., Happé 1993; Surian et al. 1996; Loukusa et al. 2006; Paul and Cohen 1985; MacKay and Shaw 2005; Ozonoff and Miller 1996; Martin and McDonald 2004). The variety of impaired pragmatic meanings identified by this seminal research may lead to the impression that any context-dependent aspect of utterance interpretation is problematic for people with ASD (see, for instance, Kim et al. 2014, p. 247). In other words, a cognitive feature inherent in ASD would uniformly affect all areas of pragmatic interpretation. This idea of an across the board pragmatic impairment in ASD is reflected in the current autism nosology. The latest edition of the Diagnosis and Statistical Manual of Mental Disorders (DSM-V) includes difficulties with non-literal utterances as one of the diagnostic criteria for ASD:

> Difficulties understanding what is not explicitly stated (e.g., making inferences) and nonliteral or ambiguous meanings of language (e.g., idioms, humor, metaphors, multiple meanings that depend on the context for interpretation) (DSM-V, American Psychiatric Association 2013, p. 48).

Another clinical feature that came to light contemporaneously to research on pragmatics in autism is the difficulty people with ASD experience in accessing other people's mental states. Even though some individual variation exists, this feature of autism has been robustly attested through a variety of methods across the spectrum (e.g., Happé 1995; Joliffe and Baron-Cohen 1999; Yirmiya et al. 1998; Heavey

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et al. 2000; Senju et al. 2010). Now, a widespread conception of pragmatic processing is to think of it as inherently rooted in inferences about the speaker's beliefs and desires, viz. in the 'Theory of Mind' cognitive component (e.g., Sperber and Wilson 2002). To be sure, such a through-and-through 'mentalistic' conception of pragmatics faces strong empirical challenges, and is viewed as theoretically inadequate by many (Recanati 2004; Breheny 2006; Perkins 2007; Kissine 2012, 2013, 2016; Andrés-Roqueta and Katsos 2017). Nonetheless, it remains extremely popular, especially outside linguistics. This is why it may have seemed natural to assume that failure to integrate the speaker's intentions and beliefs should cause people with ASD to inappropriately stick to literal meanings, and to fail to integrate context within the interpretation process (Baron-Cohen 1992, 2000; Happé 1995). However, such a 'uniform pragmatic impairment' view, caused by a Theory of Mind deficit, is challenged by a consistent set of empirical data, to which we turn now.

Preserved Pragmatic Skills

Among the pragmatic aspects of language interpretation singled out by the DSM-V as impaired in ASD, several may actually be intact. In a landmark publication, Norbury (2005) found that children with autism have no intrinsic difficulties in metaphor comprehension. These children also draw on contextual information to resolve lexical ambiguity (Norbury 2005; see also Brock et al. 2008). Likewise, Hermann et al. (2013) found no difference in the 'metaphor interference effect' (Glucksberg et al. 1982) between ASD and neuro-typical (NT) adults. Participants in both groups took longer to judge as literally false sentences that could receive a metaphorical interpretation, such as (1), than those, such as (2), for which a metaphorical reading was not (readily) available.

(1) Some jobs are jails.
(2) Some birds are jails.

In the same vein, two studies independently reported evidence of derivation of so-called 'scalar' inferences in ASD. The crucial evidence, reported by Pijnacker et al. (2009) and Chevallier et al. (2010), is that adults with ASD tend to judge sentences such as (3) and (4) as false to the same extent as NT controls.

(3) Some sparrows are birds.
(4) Zebras have black or white stripes.

Terms like *some* and *or* may be placed on a scale with stronger items, by which they are entailed; thus *all* entails *some* and *and* entails *or*. Accordingly, (3) and (4) are literally true. Judging them as false is indicative of the fact that *some* is interpreted as *some, but not all*, and that *or* is interpreted as *and, not both*. Such interpretations consist in associating the weaker term of a scale (viz. *some* and *or*) with the negation of their stronger scale-mate, hence the term 'scalar inference'. Scalar inferences are traditionally reconstructed as involving the assumption that if the speaker had sufficient evidence that the stronger alternative—*all* for *some*, and *and* for *or*—is true, s/he would have used it (Grice 1975). For this reason, the derivation of 'scalar' implicatures in ASD also strongly suggests that pragmatic processing is partly intact.

'Linguistic' Pragmatics?

Interestingly, receptive vocabulary emerged as a crucial predictor of metaphor comprehension from Norbury (2005)'s study. Both Pijnacker et al. (2009) and Chevallier et al. (2010) also suggest that higher rate of scalar inferences—that is, of pragmatic, 'false' responses to sentences like (3) and (4)—correlates, to a certain extent, with receptive language skills. The capacity to modulate one's lexical category, in a way to flexibly apply to new referents, without necessarily making assumptions about the speaker's communicative intentions, may suffice to accurately process most of the routine instances of metaphor (Wearing 2010). Likewise, lexical knowledge, together with a certain preference for informativeness could prompt the derivation of scalar inferences, without the mediation of complex mind-reading (Andrés-Roqueta and Katsos 2017). The important role played by structural language in metaphor and scalar implicature may suggest that people with ASD would have no difficulties in those pragmatic tasks only on which successful performance is determined by language skills. The distinction between linguistically determined, and more uniform, speaker-oriented pragmatic processes could explain, then, why people with ASD may understand metaphors and derive scalar inferences. However, as we will see now, this idea is difficult to apply to data on indirect requests, which suggest a still broader range of preserved pragmatic abilities in ASD.

Indirect Requests

When a request is performed with an interrogative or a declarative sentence (which, in a different context, may receive a non-directive interpretation), this request is said to be *indirect* (e.g., Searle 1975, pp. 118–122; Kissine 2013, pp. 20–21; Jary and Kissine 2014). For instance, while the imperative sentence in (5) is a direct request, the requests in (6), (7) and (8) are clearly indirect.

(5) Close the door.
(6) Could you close the door?
(7) Is it possible to close the door?
(8) It's cold in here.

Some forms, such as the *Could you_*? construction in (6), may become conventionally associated with the performance of requests. For such 'conventionalised' indirect requests, the directive interpretation may be part of lexical knowledge. For non-conventionalised cases like (7) and (8), however, the linguistic form cannot lead to the directive interpretation; it is only by taking the context into account that one may understand that (7) is not a question or (8) not a mere assertion, but a request to act on.

It has been claimed that people with ASD fail to understand indirect requests (Paul and Cohen 1985; MacKay and Shaw 2005), which would be consistent with a 'linguistic pragmatics only' view of autism, outlined in the previous sub-section. However, the conclusions of these studies are mitigated by several methodological limitations (for a detailed discussion, see Kissine et al. 2012). For instance, the indirect request forms to which participants with ASD did not react in Paul and Cohen (1985) involved considerable linguistic complexity; in fact, the very same stimuli are also difficult to process for NT adults (Clark et al. 1975). As for MacKay and Shaw (2005), they measured indirect request comprehension by asking children to explain utterances by protagonists in an illustrated story; such a meta-communicative task does not necessarily reflect indirect request comprehension.

By contrast, in a naturalistic study, Kissine et al. (2012) observed that 4–12-year-old children with ASD (and non-verbal IQ scores below typical range) comply as much with direct as with indirect requests. Furthermore, Kissine et al. (2015) found that 7–12-year-old children with ASD accurately interpret (9) as a request to put a hat on a Mr. Potato Head™ by one speaker, and as a comment on a picture in a magazine by another speaker.

(9) Oh! He has no hat.

Data reported by Kissine et al. (2012), (2015) suggest that indirect request interpretation in ASD does not necessarily require going through inferences about the speaker's meaning. Kissine (2012, 2013, 2016) proposes to distinguish between shallower pragmatic processes that draw on contextual factors to select between several available meanings, but do not require adopting one's conversational partner's perspective, and those that are rooted in complex mind-reading abilities. The former may be preserved in ASD; by contrast, the latter, which underpin genuinely inter-subjective pragmatics, are likely to be impaired. On this view, one should not expect people with ASD to necessarily stick to the literal meaning when the adequate interpretation may be reached on an assessment of context that is carried out from an 'egocentric' perspective (Shintel and Keysar 2009), viz. without making hypotheses about the speaker's mental states.

Irony

Grasping irony usually requires multilayered attribution of mental states to the speaker (e.g., Bryant 2012). The only difference between a lie and a joke is that in the latter case the speaker assumes that it is mutually obvious, to her and the addressee, that the content of her statement is false. In other words, irony comprehension requires the attribution of at least second-order mental states, viz. beliefs about somebody else's beliefs. This type of complex mind-reading—belonging to 'second-order Theory of Mind'—is usually mastered only by the age of seven in typical development (Perner and Winner 1985). Accordingly, successful comprehension of irony does not emerge before late childhood (Filippova and Astington 2008).

Since irony comprehension is deeply grounded in reasoning about the common ground, well beyond egocentric contextual processing, it is clearly an aspect of language use in which one should expect people with ASD to experience strong difficulties (Kissine 2012, 2013, 2016). And, indeed, adults with ASD have been shown to exhibit poor performance in irony comprehension, as measured by stories completion or interpretation tasks (Happé 1993; Kaland et al. 2002; Martin and McDonald 2004). Failure to detect irony in such tasks appears, furthermore, to be linked to difficulties in second-order Theory of Mind.

However, Chevallier et al. (2011) report that adults with ASD could accurately discriminate between ironic and literal interpretations based on the utterance prosody. When the target in an item such as the following was uttered with a marked ironic prosody, participants with and without ASD correctly opted for the ironic option:

> Glenn tells Phil that he decided to come by plane rather than by train.
> Ben says: How clever of you! [*Target*]
> Ben really thinks that Glen was quite right because the trains are always late. [*Option 1*; admiration]
> Ben actually thinks that Glenn is silly because the plane takes longer than the train. [*Option 2*; irony]

The authors propose that observed pragmatic deficits in autism owe less to intrinsic perspective-taking deficits than to difficulties in integrating multiple social cues in real life interactions. In line with the 'Social Motivation Theory' of autism (Chevallier et al. 2012), it could be, then, that the explanation for pragmatic deficits in ASD should draw on lack of impetus to spontaneously engage in allocentric

Table 1 Predictions of different conceptions of pragmatics in ASD

	Conventionalised indirect requests	Non-conventionalised indirect requests	Irony
Uniform pragmatic impairment	✗	✗	✗
Lexical pragmatics only	✓	✗	✗
Egocentric pragmatics	✓	✓	✗
No pragmatic impairment	✓	✓	✓

perspective shifting, rather than on pragmatic processing or perspective-shifting difficulties per se.

In the same vein, in Pexman et al. (2011)'s study of irony in children with ASD, ironic stimuli consisted in contextually incongruent comments, uttered with a marked tone of voice (e.g., one puppet commented 'That was a great play' as the other one kicked the ball missing the net). Choosing between two objects, a 'nice' duck and a 'nasty' shark, went proxy for children's understanding of the sarcastic ('nasty') nature of the puppet's comment. On this measure, Pexman et al. (2011) found no difference between ASD and typically developing children.

Using forced-choice discrimination between ironic and literal interpretation, Wang et al. (2006) also report above chance performance in adolescents with ASD on ironic items, tagged by contextual incongruence and marked prosody. However, their performance was also significantly lower than that of NT participants, and associated with different neural activation patterns. Colich et al. (2012) find comparable performance between ASD and NT participants in a forced-choice discrimination task where all ironic items are tagged by contextual incongruence, marked prosody and specific facial expression; again, however, neural response differed between the two groups.

All in all, it is unclear to which extent Chevallier et al. (2011)'s and Pexman et al. (2011)'s results reflect genuine irony comprehension. Their tasks consisted in correctly discriminating between two interpretations, the ironic one being conspicuously incongruent with the literal meaning of the target. That participants with ASD could accurately pair distinctive ironic prosody with such an incongruent interpretation is a remarkable result. But discriminating between literal and ironic interpretations is different from genuinely inferring the speaker's intended meaning in real life. Individuals with autism may use a compensatory strategy to successfully single out ironic remarks in paradigms where these are systematically coupled with contextual incongruence and/or distinctive prosody. Such data, however, hardly mirror daily-life situations, where irony does not bear such systematic properties, and the interpreter's task, beyond merely tagging utterances as 'ironic' or 'sincere', is to figure out the meaning intended by the speaker. In sum, while forced-choice discrimination tasks may highlight the capacity to associate a specific tone of voice or facial expression with contextual incongruence, they probably overestimate actual pragmatic processing in people with ASD.

This Study

Table 1 summarises the predictions made by conceptions of pragmatics in ASD surveyed above. The minimal departure from the idea of a uniform pragmatic impairment is to assume that pragmatic aspects of language interpretation can be preserved in ASD only if they have a strong linguistic basis. In constructions such as *Could you_?*, the indirect directive interpretation is conventionally associated with the linguistic form. Albeit context-dependent, such indirect requests are thus strongly grounded in language knowledge, and should therefore be comprehended by adults with ASD. By contrast, because the directive interpretation of non-conventionalised indirect requests cannot be figured out from the linguistic form, on a 'linguistic pragmatics only' view, they should be out of the scope of preserved pragmatic competence in ASD.

Indirect request processing, then, is a perfect testing ground to (*a*) provide further empirical confirmation that pragmatic impairment is not uniform in ASD, and (if it is not) (*b*) to determine whether preserved pragmatic skills are necessarily linguistically dependent. As already mentioned above, to assess genuine interpretative competence—especially in ASD—one should privilege on-line, act-out tasks over paradigms that involve meta-linguistic assessments. We opted for the act-out task developed by Ruytenbeek et al. (2017, Exp. 1), which provides on-line measures of the activation of indirect request interpretations and allows to compare them to direct request interpretations. On a 'linguistic only pragmatics' view, one should expect people with ASD to derive indirect requests interpretations for conventionalised forms only. By contrast, according to Kissine (2012, 2013, 2016), one should expect adults with ASD to reach indirect interpretations in conventionalised and non-conventionalised forms alike.

However, according to the model defended by Kissine (2012, 2013, 2016), adults with ASD should have marked difficulties with irony understanding, even though they comprehend non-conventionalised indirect requests. By contrast, if, as proposed by Chevallier et al. (2012, 2011,

Table 2 Participant characteristics

Measure	Group	N	Mean (SD)	*t*	*p*-value	*d*
Age (years)	ASD	24	27.46(11.55)	− .04	.97	− .01
	NT	24	27.58(11.47)			
Family Affluence Scale	ASD	24	9.13(2.43)	− 1.00	.32	− .29
	NT	23	9.94(3.08)			
ADOS	ASD	24	10.29(3.46)			
	NT	24	.88(1.36)			

2010), there is no specific pragmatic deficit inherently associated with ASD core features, one should expect no such systematic dissociation between indirect request derivation and irony comprehension. In order to adjudicate between these two hypotheses, it is important to design a task that mirrors, as much as possible, the challenges posed by irony in real-life. In particular, two methodological requirements emerge from our earlier discussion of irony in ASD. First, one should favour interpretation tasks, where participants must access the speaker's intended message in the same way as its addressee, over discrimination paradigms, which offer a forced-choice between 'ironic' versus 'literal' tags. Second, ironic stimuli should not be systematically associated with the same (combination of) cues. These conditions are met by the act-out task designed by Deliens et al. (2018, Exp. 2).

Methods

Participants

Forty-eight French speaking adolescents and young adults took part in the study: 24 participants with ASD (8 women, 16 men, mean age ± standard deviation = 27.47 ± 11.56; range 15–52) were pairwise matched for gender and age (± 1-year difference) to neurotypical (NT) participants (27.59 ± 11.48 years old; range 15–53). There was no difference between groups in socio-economic background, as assessed by the family affluence scale (FAS); (Currie et al. 1997). ASD participants were recruited from the Autism in Context: Theory and Experiment (ACTE) register of volunteers, through the Autism Reference Center (Autrement), at the Hôpital Universitaire des Enfants Reine Fabiola and from a secondary school for adolescents with ASD. NT participants were recruited through announcements placed on the internet. Study inclusion criteria for both groups included: (a) age between 15 and 60 years; (b) a global IQ above 70, (c) a verbal IQ above 70, (d) normal or corrected-to-normal vision and audition and, (e) for NT participants, no known psychiatric, developmental or neurological disorders. Twenty-one participants with ASD had previously received a clinical diagnosis of ASD from a multi-disciplinary team assessment, external to our research group, based on the Autism Diagnostic Observation Schedule (ADOS); (Lord et al. 2012) and the Autism Diagnostic Interview-Revised (ADI-R); (Le Couteur et al. 2003) criteria. The clinical diagnosis of ASD was confirmed for all participants (ASD and NT) by a research-accredited ADOS assessor using the ADOS; (Lord et al. 2012). An additional seven participants with ASD were involved in the study but were not included in the final data set. Of these, four had a global or verbal IQ below the inclusion criteria, one scored above the clinical cut-off for ASD on the ADOS and the last one was excluded because of poor eye-tracking data in the two experimental tasks. Four participants with ASD also held a diagnosis of Attention-Deficit/Hyperactivity Disorder (ADHD). Statistical analyses were run with and without these participants and the results did not change. NT participants were compensated for their time upon the entire completion of study procedures (15 euros). Participant characteristics are summarised in Table 2.

Material

All computerised tasks were run in 64-bit Windows 7 with a 16.5-in. monitor (resolution: 1920 × 1080 pixels). Tobii Studio™ 3.4.6 software was used to set up, run, and analyse data of the irony and indirect request tasks. Participants gaze behaviour was recorded using Tobii pro X2-60(Hz) screen-based eye-tracker device (Tobii Technology, Inc., Stockholm, Sweden).

The Indirect Request Task

This task is borrowed from Ruytenbeek et al. (2017, Exp. 1). The experimental design includes 24 trials, consisting in a combination of an audio presentation of a sentence (in French) with a video display of a grid containing coloured shapes and, beneath it, two buttons, yes and no (see Fig. 1). The sentences, spoken by a female voice, distributed across the four following types, six per type: control imperatives, control interrogatives, *Can you* _? interrogatives, and *Is it possible to* _? interrogatives. Examples for each category, in English, are given in (10)–(13).

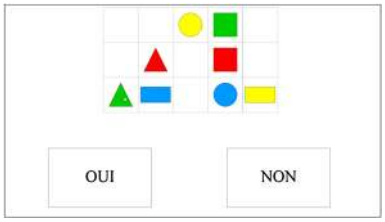

Fig. 1 Indirect request task: example of a grid associated with a trial. (Color figure online)

(10) Move the red circle to the left of the yellow rectangle. [control imperative]
(11) Is the red circle on the left of the yellow rectangle? [control interrogative]
(12) Can you move the red circle to the left of the yellow rectangle? [*Can you* _? interrogative]
(13) Is it possible to move the red circle to the left of the yellow rectangle? [*Is it possible to* _? interrogative]

Control imperatives can be responded to only by moving a shape in the instructed position in the grid, while control interrogatives can be responded to only by answering *yes* and *no*. For all the grids, the two objects referred to by the sentence can only be singled out by taking into account both their shape and colour. Moving a coloured shape was possible only if the position in the grid, referred to in the sentence, was empty (this rule was implicit to the task). For the imperative sentences, it was always possible to move the shape as indicated in the sentence. For all the interrogative sentences, there was an equal number of trials where the movement was possible (and the correct answer to the corresponding question was *yes*) and those where it was not (and the correct answer to the corresponding question was *no*). Therefore, half of the *Can you* _? and *Is it possible to* _? can be responded to either by answering to the question or by moving the shape, the latter response evidencing an indirect request interpretation. A corpus exploration reported in Ruytenbeek et al. (2017) confirms that the French equivalents of *Can you* _? and *Is it possible to* _? differ as to their degree of conventionalisation as indirect requests: the predominant use of the former construction is the performance of indirect requests, while the latter is mostly used for asking questions.

The presentation of each sentence was associated with a grid consisting in a different arrangement of eight geometrical shapes (two triangles, two circles, two squares, and two rectangles) of four possible colours (yellow, red, green, and blue). Five lists were created, in which the order of the 24 trials was randomized; the participants were randomly assigned to a list (see for further details Ruytenbeek et al. 2017, Exp1).

Irony Task

The irony task is borrowed from Deliens et al. (2018, Exp. 2). It consists in 38 videos (36 experimental and two practice) of two French-speaking characters (A & B) interacting while sitting around a table on which two objects are set. Video frames are composed of four consecutive segments (see Table 3). In the *context segment*, character A makes explicit character B's preferences for one of the two objects (e.g., 'George, I know that you like wearing blue clothes and that you really don't like red clothes. But a red t-shirt would be nice to wear.'). In *the labelling and question segment*, A explicitly names and points at the two objects on the table (e.g., 'Here is a blue t-shirt and here is a red t-shirt.'), and then, asks B if s/he wants one of the two objects (e.g., 'Would you like the red t-shirt as a gift, now?'). The labelling and question segment is followed by the *pause segment* in which a black screen appears until participants press the space bar to hear character B's reply. The trial ends with the *target segment*, i.e., B's reaction (e.g., 'Yes, you know how much I like red clothes!'). Participants are instructed to click on the right mouse button if they believe character B really wants the object at the right of the screen and on the left mouse button if they believe character B really wants the object at the left of the screen. The video freezes until participants respond.

The 36 experimental videos relied on 12 scenarios. By changing the contextual information and the beginning of

Table 3 Irony task: time course of three versions (Literal No, Ironic and Literal Yes) of a scenario

	Literal No	Ironic	Literal Yes
Context	George, I know that you like football and that you really don't like basketball. But playing basketball could be fun too.		George, I know that you like basketball and you have said this to me many times.
Label and question	Here is a football and here is a basketball.	Would you like to play with the basketball, now?	
Pause	Press the space bar to hear George's reply.		
Target	No, you know how much I hate basketball!	Yes, you know how much I like basketball!	

the target sentence ('Yes, you know how much I like X' vs. 'No, you know how much I hate X'), three versions of each scenario were created: a version where the meaning of the target sentence was Ironic, sincere positive (Literal Yes) and sincere negative (Literal No).[1] An example of the three versions of a scenario is given in Table 3.

The structure of Deliens et al. (2018)'s irony task is close to the act-out irony detection task designed by Kowatch et al. (2013). Aside from the use of real speakers instead of puppets, the most important advantage of Deliens et al. (2018)'s paradigm is that ironic items are not systematically associated with a certain type of cue. In each scenario, the meaning of the target sentence was supported by the presence of specific cues depending on the six conditions: Context only (C), Prosody only (P), Context and Prosody (CP), Context and Facial expression (CF), Prosody and Facial expression (PF), and Context, Prosody and Facial expression (CPF). In the two conditions devoid of contextual cues (P and PF conditions), the context segment of the video was removed. In conditions where prosodic cues were available (P, CP, PF and CPF conditions), the character produced the target sentence with the matching prosody (sincere positive for Literal Yes items, sincere negative for Literal No items and ironic for Ironic items). In the absence of prosodic cues (C and CF), the target sentence was uttered in a monotonous tone of voice. Similarly, in conditions where facial expression cues were available (PF, CPF, CF), the character uttered the target sentence with the corresponding facial expression, while neutral facial expressions were used in the other conditions (P, CP, C). Three professional actors were hired to shoot the videos. Facial expressions and prosody used in the videos have been independently validated in Deliens et al. (2018, Exp. 1). In total, participants saw 38 videos, two videos intended for training trials (one Literal Yes and one Literal No item) and 36 experimental videos: 12 Ironic, 12 Literal Yes and 12 Literal No. For each type of statement (Literal Yes, Literal No, Ironic), there were two items per condition (C, P, CP, CF, PF, CPF).

[1] In order to make the task as non-challenging as possible for ASD participants, our design did not include negative ironic sentences, which would correspond to 'ironic compliments'. Pexman et al. (2011) found a floor performance on ironic compliments for children with autism (as well as for age- and verbal-matched typically developing children). Such forms of irony are much less canonical (Kreuz 2000), and are very difficult to grasp, be it by adults (Climie and Pexman 2008) or children (Filippova and Astington 2008). This methodological choice should have no impact on potential group differences on ironic items. This is especially so because, using exactly the same design, Deliens et al. (2018) found no evidence that NT participants would rely on the fact that negative statements are always sincere.

Background Measures

In addition to indirect request and irony tasks, we collected three supplementary sets of measures. First, verbal performance and full-scale IQ were assessed using the Wechsler Adult Intelligence Scale (WAIS-IV; Wechsler 2008). Second, as advised by Baron-Cohen et al., the Empathy Quotient EQ (Baron-Cohen and Wheelwright 2004) was administered conjointly with the Autism spectrum Quotient AQ (Baron-Cohen et al. 2001), which provides an estimate of the number of autistic-like traits presented by an individual, and allows to situate them on the continuum from autism to neuro-typicality. Third, participants were assessed on the main three executive components linked with pragmatic abilities: inhibition, cognitive flexibility and planning ability (for a review see Monetta and Champagne 2004; Martin and McDonald 2003). A Stroop task (Mary et al. 2016) was administered to measure conflict resolution and inhibitory control abilities. Cognitive flexibility was assessed using the Wisconsin Card Sorting Task (Berg 1948) which measures the participant's ability to switch from one rule to another. Finally, we administered the Tower of London task (Shallice 1982) to measure planning abilities.

Procedure

This study was conducted in three sessions. The Wechsler Adult Intelligence Scale and the Counting Stroop task were administered during the first session. During the second session, participants were seated at a distance of ± 60 cm in front of a computer screen. Following a five points calibration procedure, participants completed the irony task. After the irony task, a second calibration procedure was performed followed by the completion of the indirect request task. The second session ended by the administration of the Wisconsin Card Sorting Task and the Tower of London task. Finally, the third session consisted in the administration of the Autism Diagnostic Observation Schedule.

Statistical Analysis

Unless indicated otherwise, all results were analysed in R (R Core Team 2016) building generalised multilevel regressions in the lme4 package (Bates et al. 2015). Significance of the fixed effects was assessed by performing likelihood ratio tests in which a model containing the fixed effect is compared to another model without it but that is otherwise identical in random effect structure (Barr et al. 2013). Post-hoc comparisons of least square-means, with Tukey adjustment for multiple comparisons and Satterthwaite method for estimating degrees of freedom, were implemented in the lsmeans package (Lenth 2016).

Results

The Indirect Request Task

Four participants with ASD were excluded from statistical analyses: two participants completed an old version of the task, one had an anxiety attack that prevented him to finish the task, and the fourth did not understand the task.

Response patterns were analysed in order to determine whether participants with ASD were more likely to assign a literal, 'question' interpretation to conventionalised *Can you move* _? or non-conventionalised *Is it possible to move* _? indirect requests. Responses to the spoken sentences were classified into answers (clicking on *yes* or *no* buttons) and moves (moving a shape in the grid). Evidence that an interrogative sentence is interpreted as a question (request for information) would be an answer to the question expressed. Evidence for a directive, request for action interpretation of an interrogative would be that, upon hearing the sentence, the participant moves the shape as indicated by the sentence instead of answering 'yes' to the question. We restricted the analysis to those stimuli for which the correct response was 'yes', and hence, for which it was possible to respond by moving the shape mentioned in the sentence. We excluded errors ($n = 9$ for the ASD group; $n = 2$ for the NT group) and missing values ($n = 3$ for the ASD group).

Response latencies were analysed to determine whether indirect request interpretation is costlier in ASD than in NT participants. Response times to different sentences were defined as the length of time comprised between the moment when the first coloured shape was spoken out in the sentence (computed with Audacity 2.0.6™ and coded in Tobii Studio™) and the mouse click on the *yes/no* buttons (for 'yes'/'no' answers) or the first mouse click on a shape in the grid (for 'move in the grid' responses). Only response times to correct responses were included within the analysis.

For the total durations of the fixations on the area of interest encompassing the *yes* and *no* buttons and the small area in-between, the segments started when the first coloured shape was spoken out in the sentence and ended as soon as the first left mouse click occurred (either to select a shape or to click on the *yes* or *no* button). Longer fixations on the buttons during a move response to an indirect request indicate hesitation towards a 'question' interpretation.

Response Patterns

As can be seen from Fig. 2, participants with ASD did not provide less directive interpretations of indirect requests than NT participants. Quite on the contrary, it seems that NT, but not ASD, participants gave less directive interpretations to non-conventionalised *Is it possible* _? indirect requests.

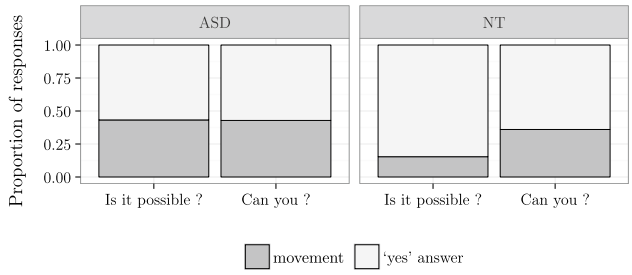

Fig. 2 Indirect request task: proportion of responses—movement of the shape or click on the 'yes' button—per sentence type by group

Hierarchical logistic multilevel regressions, with by-participant intercepts as random factor, revealed a significant effect of Indirect request type ($\chi^2(1) = 7.69$, $p = .005$), as well as an interaction Indirect request type X Group ($\chi^2(1) = 6.67$, $p = .035$). Post-hoc comparisons confirmed that NT participants provided less 'move' responses to non-conventionalised *Is it possible* _? than to conventionalised *Can you* _? indirect requests ($\beta = -2.61, SE = .9, z = -2.89$, $p = .02$).

Response Times

Figure 3 displays mean response times. Starting with response latencies in movement responses—indicative of directive interpretations—in indirect requests relative to control imperatives (for which no other response was possible). Hierarchical multilevel linear regressions, with by-participants and by-items intercepts in the random structure, revealed an effect of Group ($\chi^2(1) = 5.34$, $p = .02$), with shorter response times in the NT group ($\beta = -739, SE = 317, t(44.26) = -2.33$, $p = .024$) as well as an interaction Group X Type of sentence ($\chi^2(4) = 17.46$, $p = .002$). Post-hoc comparisons revealed that directive interpretations of non-conventionalised *Is it possible* _? indirect requests took longer relative to imperatives in the ASD group ($\beta = 1338, SE = 367, t(53.09) = 3.65$, $p = .008$), and that conventionalised *Can you* _? indirect requests took longer relative to imperatives in the NT group ($\beta = 1047, SE = 356, t(53.09) = 2.93$, $p = .05$). There were no further significant contrasts within each group ($ps > .37$) and, per Type of sentence, between the two groups ($ps > .2$).

Turning to response latencies in 'yes' responses—indicative of a literal, 'question' interpretation—to indirect requests relative to control interrogatives (for which the correct response was 'yes'). Hierarchical multilevel linear regressions, with by-participants and by-items intercepts in the random

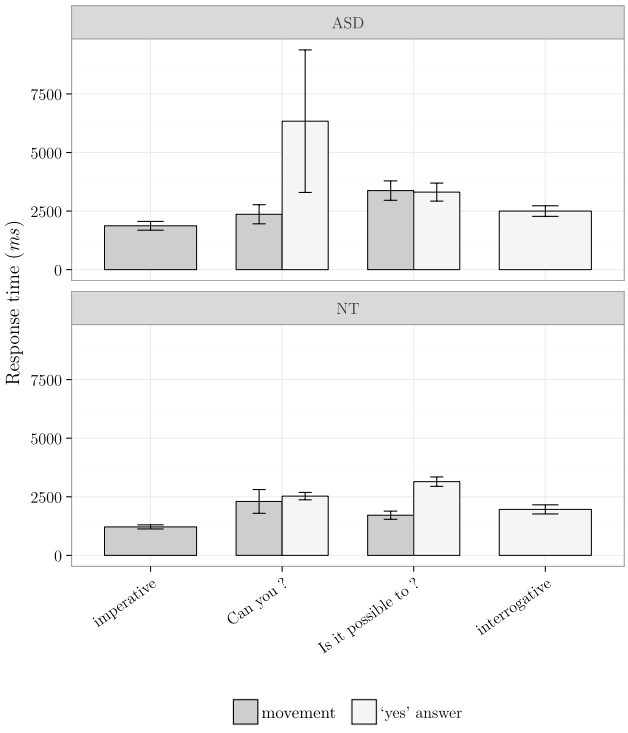

Fig. 3 Indirect request task: response time per response—movement of the shape or click on the 'yes' button—and sentence, by group (vertical bars represent standard errors of means)

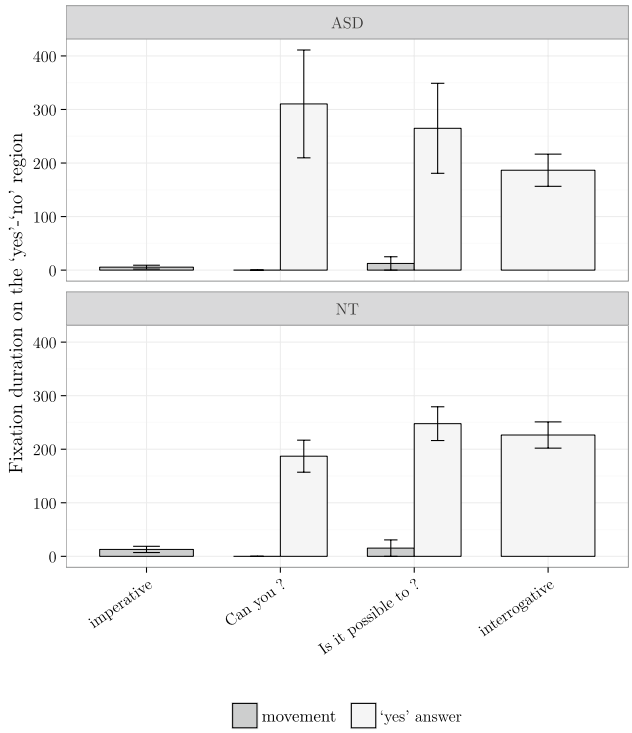

Fig. 4 Indirect request task: mean fixation durations on the *yes/no* buttons per response and sentence, by group (vertical bars represent standard errors of means)

structure, revealed no effect of Group ($\chi^2(4) = 14.08$, $p = .1$) and of Type of sentence ($\chi^2(2) = 5.19$, $p = .075$); however, there was a significant interaction Group X Type of sentence ($\chi^2(5) = 16.85$, $p = .005$). Post-hoc comparisons confirmed that, as can be seen from Fig. 3, participants with ASD took longer in providing a literal response to conventionalised *Can you* _? indirect requests relative both to control interrogatives ($\beta = 4412, SE = 1173, t(31.51) = 3.76$, $p = .008$) and to the literal responses to conventionalised *Can you* _? indirect requests in the NT group ($\beta = 4271, SE = 1296, t(164.8) = 3.3$, $p = .015$). There were no further significant contrasts within each group (*p*s> .22) and, per Type of sentence, between the two groups ($p > .97$).

Indirect request task: response time per response—movement of the shape or click on the 'yes' button—and sentence, by group (vertical bars represent standard errors of means)

Fixations on Yes/No Buttons

As can be seen from Fig. 4, which summarises mean fixation durations on the 'yes' and 'no' buttons, directive interpretations were associated with almost no fixations on the *yes/no* buttons. Hierarchical multilevel linear regressions, with by-participant and by-item intercepts in the random structure, confirmed that, for 'move the shape in the grid' responses, there was no effect of Group ($\chi^2(1) = .57$, $p = .45$) and of Type of sentence ($\chi^2(3) = 1.88$, $p = .39$), and no Group X Type of sentence interaction ($\chi^2(5) = 2.97$, $p = .7$).

The Irony Task

A correct interpretation of a target corresponds to a trial where the participant accurately selects the object the second character (B) in the video really wants (see the description of the stimuli). For Literal Yes items, the correct choice was the object named in the target sentence (e.g., 'Yes, you know how much I like physics!'), whereas for Literal No (e.g., 'No, you know how much I hate physics!') and Ironic items (e.g., 'Yes, you know how much I like physics!'), it was the other object displayed in the video.

In order to uncover potential group differences in terms of attention paid to the speaker and in processing reference to the (in)correct object, we analysed participants' eye-movements during the utterance of the target sentence. We identified four areas of interest (AOI) for the target sentence segment using Tobii Studio software (version 3.2.1): the speakers eyes, speaker's mouth, the correct object and the incorrect object. The position of the AOI was manually adapted to the movements of the two actors in real time from the onset of the word referring to an object in the target (e.g.,

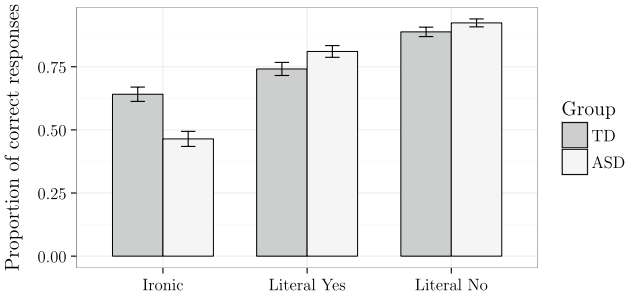

Fig. 5 Irony task: proportions of correct responses by utterance Type and by Group (vertical bars represent standard errors)

physics in 'Yes, you know how much I like *physics*!') until participants' response. For each AOI, we calculated the total fixation duration (i.e., the sum of the durations for all fixations within an AOI), normalised according to the time the participant needed to respond.

Accuracy

An inspection of mean proportions of correct responses, per item Type (*Ironic* vs. *Literal Yes* vs. *Literal No*) in Fig. 5 suggests that Ironic items are more difficult than Literal Yes and No, especially so for the ASD group. Multilevel logistic regressions, with by-participants in the random structure revealed a significant Type effect (*Ironic* vs. *Literal Yes* vs. *Literal No*; $\chi^2(2) = 204.83$, $p < .001$), as well as an Interaction Type X Group ($\chi^2(2) = 23.67$, $p < .001$), but no effect of the order of appearance of the item ($p = .76$). Post-hoc comparisons confirmed that accuracy on Ironic items was significantly lower in the ASD than in the NT group ($\beta = -.77, SE = .24, z = 3.2$, $p = .017$), but not for Literal Yes and Literal No ($ps > .6$) items. Additionally, for ASD participants accuracy on Ironic items was significantly lower compared to Literal Yes ($\beta = -1.7, SE = .2, z = -8.49$, $p < .001$) and Literal No ($\beta = -2.77, SE = .25, z = -10.7$, $p < .001$) items. For NT participants accuracy on Ironic items was also lower compared to Literal No ($\beta = -1.57, SE = .23, z = -6.84$, $p < .001$), but not to Literal Yes ($p = .078$) items.

In order to assess the impact of different cues on irony comprehension, we associated each stimuli with a binomial variable Context, Prosody and Facial expression, depending on the cue(s) associated with the target utterance. Multilevel logistic regression with by-participant intercepts in the random structure yielded significant triple interactions Type X Group X Context ($\chi^2(6) = 25.23$, $p < .001$), Type × Group × Prosody ($\chi^2(6) = 18.22$, $p < .006$) and Type × Group × Facial expression ($\chi^2(6) = 86.38, p < .001$).

All post-hoc comparisons were restricted to the Ironic level of the Type factor. In addition to being the level of interest, recall also that this is the only type of item on which ASD and NT participants' accuracy scores differ. The presence of context increased accuracy both in the ASD ($\beta = .93, SE = .27, z = 3.38$, $p = .004$) and in the NT ($\beta = .69, SE = .37, z = 2.58$, $p = .048$) groups. Participants with ASD performed worse than NT participants, whether the target utterance was preceded by a contextual cue making clear the speaker's preferences ($\beta = -.71, SE = .27, z = -2.57$, $p = .05$) or not ($\beta = -.95, SE = .35, z = -2.7$, $p = .035$). By contrast, the presence of ironic prosody ($p = .22$) or facial expression ($p = .51$) did not affect accuracy in either group.

Eye Movements

Fixation durations on speaker's eyes and mouth were analysed using hierarchical multilevel linear regressions, with by-participants and by-items intercepts in the random structure. There was no Group effect on total fixation duration on speaker's eyes ($\chi^2(1) = 1.72$, $p = .19$) and on speaker's mouth ($\chi^2(1) = 1.34$, $p = .25$). There was an effect of Group on total fixation duration on the correct object ($\chi^2(1) = 5.07$, $p = .024$), as well as a Group X Type interaction ($\chi^2(4) = 35.77$, $p < .001$). Post-hoc comparisons revealed that participants with ASD fixated the correct object less in Ironic than in Literal Yes items ($\beta = -.044, SE = .009, t(57.95) = -4.93$, $p < .001$). There was also an effect of Group on total fixation duration on the incorrect object ($\chi^2(1) = 6.67$, $p = .01$), as well as a Group X Type interaction ($\chi^2(4) = 45.62$, $p < .001$). Post-hoc comparisons revealed that participants with ASD fixated more the incorrect object in Ironic than in Literal Yes ($\beta = .045, SE = .01, t(61.34) = 5.83$, $p < .001$) and Literal No ($\beta = .03, SE = .008, t(60.99) = 3.82$, $p = .004$) items. In Ironic items, participants in the ASD group also fixated more the incorrect object than NT participants ($\beta = .057, SE = .01, t(59.82) = 4.31$, $p = .001$). Finally, for all AOIs, there was no interaction between Type X Group X Context, Type X Group X Prosody and Type X Group X Facial expression ($ps > .07$).

Background Measures

As can be seen from Table 4, there was no difference between groups in full-scale, verbal or non-verbal IQ and in none of the executive function tasks. Expectedly, relative to NT participants, participants with ASD had significantly higher scores on AQ, and significantly lower scores on EQ.

In order to test potential influence of background measures on the pragmatic tasks, we separately tested each background measure using linear regression models with participant age and SES as fixed factors. The two outcome measures analysed for the indirect request task

Table 4 Background measures per group

Measure	Group	N	Mean (SD)	*t*	*p*-value	*d*
Full-scale IQ	ASD	24	108.04(18.05)	.05	.96	.01
	NT	24	107.833(11.01)			
Verbal IQ	ASD	24	112.04(20.41)	.15	.88	.04
	NT	24	111.33(11.98)			
Non verbal IQ	ASD	24	108.92(14.52)	1.45	.15	.42
	NT	24	103.54(10.92)			
Autism spectrum Quotient (AQ)	ASD	22	34.96(8.36)	10.51	< .001	3.17
	NT	22	12.18(5.77)			
Empathy Quotient (EQ)	ASD	22	23.64(11.38)	− 4.70	< .001	− 1.42
	NT	22	39.23(10.59)			
Stroop						
Time interference index	ASD	23	−26.26(22.47)	− .41	.68	− .12
	NT	24	−24.04(13.27)			
Error interference index	ASD	23	−.74(1.01)	− .97	.34	− .28
	NT	24	−.42(.75)			
Tower of London						
Total time	ASD	22	575.92 (144.93)	− .75	.22	− .37
	NT	24	672.50 (338.36)			
Extra moves	ASD	22	74.86 (48.03)	.49	.63	− .15
	NT	24	68.29 (43.00)			
Wisconsin Card Sorting Task						
Complete category	ASD	22	3.46 (1.41)	-.75	.21	− .37
	NT	24	3.96 (.75)			
Perseverative errors	ASD	22	13.63 (13.06)	1.14	.26	.34
	NT	24	10.42 (4.41)			
Non-perseverative errors	ASD	22	9.98 (10.45)	− .25	.81	− .07
	NT	24	10.81 (11.96)			

we used were the proportion of 'move shape in the grid' responses to non-conventionalised request forms, and the proportion of 'move shape in the grid' responses to conventionalised request forms. The two outcome measures analysed for the irony task were the proportion of total correct responses and the proportion of correct responses for ironic items. Most results were clearly non-significant, and for the sake of brevity we choose not to report them here. There was a tendency for AQ scores to predict overall accuracy in the irony task ($F(3, 40) = 2.31$, $p = .09$). The interaction AQ X Group was also significant, indicating that higher AQ scores had more impact on accuracy in the ASD than in the NT group ($F(4, 39) = 2.94$, $p = 0.032$). There was a group-independent significant effect of verbal IQ on the proportion of correct responses on ironic items ($F(3, 43) = 4.35$, $p = .009$). Error interference index of the Stroop task predicted overall accuracy scores in the irony task ($F(3, 42) = 3.81$, $p = .017$), and lower proportion of 'move the shape' responses to conventionalised *Can you _*? indirect requests ($F(3, 38) = 3.37$, $p = .028$). The Number of extra moves in the Tower of London predicted a higher proportion of 'move the shape' responses to non-conventionalised requests ($F(3, 38) = 5.04$, $p = .005$) and non-conventionalised ($F(3, 38) = 3.3$, $p = .031$) request forms. The Number of complete categories in the Wisconsin Card Sorting Task predicted a higher overall accuracy on the irony task ($F(3, 41) = 3.44$, $p = .025$) and on ironic items only ($F(3, 41) = 3.33$, $p = .029$). Importantly, for all of these significant effects, the interaction with the Group factor was not significant ($ps > .07$). Additionally, even for the significant effects, $ps > .009$, and given the number of models built, it is unclear that even these results would resist a correction for multiple comparisons. In addition, there was no relationship between the outcomes of the pragmatic tasks ($ps > .09$).

Discussion

The first clear-cut result of this paper is that comprehending indirect requests is not out of reach for individuals with ASD, confirming previous findings by Kissine et al. (2015, 2012). Interrogative *Can you _?* constructions that are conventionally associated with requests elicited the same rate

of directive interpretations in ASD and NT participants. Furthermore, reaction times indicate that these interpretations did not come at a specific cost for our participants with ASD. Of course, conventionalised indirect requests are probably encoded, on one level or another, within one's lexical knowledge. To that extent, one could speculate that for individuals with ASD directive interpretations associated with conventionalised indirect speech acts are not genuinely pragmatic, but tied to a certain idiomatic construction. In that relation, recall that, in the ASD group, reaction times for non-directive responses to *Can you _?* items were significantly higher relative to control interrogatives.

However, ASD participants also evidenced directive interpretations of non-conventionalised indirect requests. Actually, for a reason that is not clear to us, they did so to a greater extent than NT participants. These interpretations were associated with longer reaction times than control imperatives in the ASD group, probably reflecting costlier contextual processing. That said, directive interpretations of both types of indirect requests were associated with virtually no fixations on the *yes/no* buttons, be it in the ASD or the NT groups. This result—which, for the NT group, replicates that of Ruytenbeek et al. (2017, Exp. 1)—is indicative of the fact that the indirect request interpretation is not necessarily mediated by a prior activation of the literal, 'question' meaning. That is, the indirect request interpretation can probably be accessed directly, without necessarily assessing the utterance literal, compositional interpretation relative to the speaker's communicative intentions (see also Gibbs 2002). Our indirect request task thus confirms that participants with ASD rely on context to go beyond the literal meaning, even in cases where the pragmatically motivated interpretation does not closely depend on the sentence form.

Such contextual meanings, however, do not require figuring out what the speaker intended to communicate, and may be reached from an entirely egocentric perspective. By contrast, in our irony task, the correct response entailed the attribution of a certain intention to the speaker. Additionally, recall that the structure of our irony task made it impossible for participants to rely on contextual incongruence, prosody and/or facial expression to reach correct responses to ironic items in a shallower way, as neither literal nor ironic items were systematically associated with (a combination of) these cue(s). Results unequivocally show that participants with ASD struggled with grasping irony, as revealed by significantly lower accuracy and longer fixation durations on the incorrect object for ironic items relative to NT participants. It clearly appears, then, that the same adults with ASD who displayed intact contextual comprehension of indirect requests, have marked difficulties in understanding irony.

Importantly, there is no reason to believe that participants with ASD lacked interest in the irony task, and did not attempt to provide correct responses. To begin with, accuracy was significantly lower in the ASD relative to the NT group in ironic items only, thus ruling out that participants with ASD responded at random. It is equally unlikely that they always opted for the literal interpretation, as the overall proportion of correct responses on ironic items neared 50%. Furthermore, the presence of contextual incongruence significantly raised the probability to reach the correct ironic interpretation. Manifest incompatibility between the utterance literal content and background context is an extremely reliable cue to irony (Gerrig et al. 2000; Kreuz and Link 2002; Deliens et al. 2018). It may thus be recruited, to a limited extent, by individuals with ASD, as a learned strategy to detect irony (Persicke et al. 2013), and, in our task, to give the response opposite to that literally mentioned by the speaker.

By contrast, in both groups ironic prosody and facial expression did not increase accuracy on ironic items. This result is not extremely surprising in itself. Deliens et al. (2018) show that, for NT adults, ironic prosody and facial expression can be correctly identified as such against sincere counterparts in a forced-choice discrimination task; however, the very same cues are less reliable in an act-out task of the type used here. Our results confirm that studies that used forced-choice discrimination tasks and systematically associated irony with contextual incongruence and marked prosody do not provide an accurate measure of actual irony comprehension in autism. Note, again, that eye-tracking data showed no differences in fixation duration on speaker's lips and eyes between groups, making it improbable that participants with ASD simply disregarded ironic prosody and/or facial expression. It appears, then, that the discrimination task used by Chevallier et al. (2011) overestimated the extent to which individuals with ASD manage to detect irony on the basis of prosodic cues.

Looking back at Table 1, our results show that preserved pragmatic abilities in ASD are not necessarily limited to processes rooted in structural language, viz. to 'linguistic pragmatics', in the sense of Andrés-Roqueta and Katsos (2017). At the same time, the very same participants with ASD who proved capable of context-based indirect request interpretation had marked difficulties in detecting irony. There was no difference in the verbal or non-verbal IQ scores, or for that matter executive functioning, between our participants with ASD and those in the NT comparison group. Participants with ASD's performance on the two pragmatic tasks can therefore not be explained in terms of verbal or non-verbal IQ. Many among our participants with ASD received interventions, which may have improved their socio-pragmatic skills and partly explain comparable performance between the two groups in the indirect request task. As discussed in the Introduction, irony comprehension is intimately linked to complex mind-reading; understanding a sarcastic speaker involves making assumptions about her beliefs, and also about her representation of

one's own mental states (e.g., Bryant 2012). This inter-subjective aspect of irony seems inherently difficult to process for people with ASD independently of their linguistic competence, IQ profile or exposure to targeted interventions.

Lack of any correlation between participants' performance on these two tasks further confirms that they tap different pragmatic capacities. Such a selective pragmatic profile makes it unlikely that pragmatics is intrinsically intact in ASD, and that observed pragmatic deficits might receive a motivational explanation (cf. Chevallier et al. 2010, 2011, 2012). There is no reason why participants with ASD would be less motivated in the irony than in the indirect request task, and, as just mentioned, eye-tracking and response patterns do not suggest any kind of disengagement from the task. Furthermore, while participants with ASD expectedly display lower empathy and lack of propensity to adopt somebody else's perspective, as measured by EQ, these features do not explain differential results on indirect request versus irony tasks.

The selective pragmatic deficit in ASD, which emerges from our results, is in line with the predictions made by Kissine (2012, 2013, 2016). According to him, the capacity to reach non-literal meanings is not intrinsically deficient in ASD, but impacts only those pragmatic processes that require genuine perspective-shifting. However, his explanation for impaired irony in ASD is couched in terms of an underlying deficit of the flexibility component of executive functions. Our data do not support the notion that irony impairment can be explained by executive function impairment. Contrary to what may be expected from the literature (e.g., Russell and Hughes 1994; Zelazo et al. 2002; Ozonoff and Rogers 1991; Hill 2004; Ozonoff et al. 2005), we did not find any group difference in our executive tasks, which tap different executive aspects that can be involved in cognitive perspective shifting. Neither did these results predict any group-specific response patterns in the pragmatic tasks. One possibility is that our participants with ASD did not exhibit any difference in executive functioning relative to the NT group. Intact executive functioning has been previously reported in ASD at the level of inhibition (Ozonoff 1997; Adams and Jarrold 2009; Bramham et al. 2009; Lai et al. 2017). Furthermore, while lack of flexibility is a clear and everyday behavioural hallmark of ASD, it is also possible that neither the Wisconsin Card Sorting Task nor the Tower of London are sufficiently fine-grained to capture the difficulties inherent in ASD executive functioning (Geurts et al. 2009; Landry and Al-Taie 2016).

Identifying the precise cognitive correlates of selective pragmatic impairment in ASD thus remains a topic for further research. What our paper does establish, however, is that these difficulties should not be explained in terms of incapacity of using context in utterance interpretation. Realising that some areas of pragmatic functioning may be intact in ASD should, by no means, obfuscate the extent of interactional difficulties individuals with ASD routinely experience in their social life. As repeatedly suggested in the foregoing, such context-based pragmatic processing is probably limited to an egocentric perspective. Intersubjective dimensions of language use, those that require to genuinely project into the interactional partner's shoes, present multiple challenges to individuals with ASD. In addition to complex perspective-shifting, they involve on-line integration of cues from multiple sources, and complex monitoring of social relations. For instance, beside high processing demands entailed by irony, its teasing function may appear incomprehensible to persons with ASD. But a picture of pragmatics in ASD that is more nuanced than the through-and-through 'over-literal' stereotype, which still dominates much of current representations of autism, does better justice to the persons on the spectrum and their needs.

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Author Contributions GD designed the experiment, recruited participants, ran testing sessions, took part in the result analyses and in the redaction of the paper. FP recruited participants and ran testing sessions. NR designed the experiment and took part in the result analyses. PG recruited participants and ran testing sessions. MK designed the experiment, analysed the results and wrote the paper.

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Compliance with Ethical Standards

Ethical Approval All procedures in this study were approved by the ethics committee of Erasme Hospital in accordance with the 1964 declaration of Helsinki and its later amendments. All adult participants provided informed consent. Adolescent participants provided informed assent with their parents providing informed consent.

References

Adams, N. C., & Jarrold, C. (2009). Inhibition and the validity of the Stroop task for children with autism. *Journal of Autism and Developmental Disorders*, *39*(8), 1112–1121.

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (DSM-5). Wasington: American Psychiatric Association.

Andrés-Roqueta, C., & Katsos, N. (2017). The contribution of grammar, vocabulary and theory of mind in pragmatic language competence in children with autistic spectrum disorders. *Frontiers in Psychology*, *8*, 996.

Attwood, A. (2015). *The complete guide to asperger's syndrome*. London: Jessica Kingsley.

Baron-Cohen, S. (1992). Out of sight or out of mind? Another look at deception in autism. *Journal of Child Psychology and Psychiatry*, *33*(7), 1141–1155.

Baron-Cohen, S. (2000). Theory of mind and autism: A fifteen year review. *Understanding other minds. Perspectives from developmental cognitive science*. Oxford: Oxford University Press.

Baron-Cohen, S., & Wheelwright, S. (2004). The empathy quotient: An investigation of adults with asperger syndrome or high functioning autism, and normal sex differences. *Journal of Autism and Developmental Disorders*, *34*(21), 63–75.

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The autism-spectrum quotient (AQ): Evidence from Asperger syndrome/high-functioning autism, males and females, scientists and mathematicians. *Journal of Autism and Developmental Disorders*, *31*, 15–17.

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*, *68*(3), 255–278.

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*, 11–48.

Berg, E. A. (1948). A simple objective technique for measuring flexibility in thinking. *Journal of General Psychology*, *39*(1), 15–22.

Bramham, J., Ambery, F., Young, S., Morris, R., Russell, A., Xenitidis, K., et al. (2009). Executive functioning differences between adutls with attention deficit hyperactivity disorder and autistic spectrum disorder in initiation, planning and strategy formation. *Autism*, *13*, 245–264.

Breheny, R. (2006). Communication and folk psychology. *Mind and Language*, *21*(1), 74–107.

Brock, J., Norbury, C. F., Einav, S., & Nation, K. (2008). Do individuals with autism process words in context? Evidence from language-mediated eye-mouvements. *Cognition*, *108*, 896–904.

Bryant, G. A. (2012). Is verbal irony special? *Language and Linguistics Compass*, *6*, 673–685.

Chevallier, C., Kohls, G., Troiani, V., Brodkin, E. S., & Schultz, R. T. (2012). The social motivation theory of autism. *Trends in Cognitive Sciences*, *164*, 231–239.

Chevallier, C., Noveck, I., Happé, F. G. E., & Wilson, D. (2011). What's in a voice? Prosody as a test case for the theory of mind account of autism. *Neuropsychologia*, *49*(3), 507–517.

Chevallier, C., Wilson, D., Happé, F. G. E., & Noveck, I. (2010). Scalar inferences in autism spectrum disorders scalar inferences in autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *40*, 1104–1017.

Clark, H. H., & Lucy, P. (1975). Understanding what is meant from what is said: A study in conversationally conveyed requests. *Journal of Verbal Learning and Verbal Behavior*, *14*, 56–72.

Climie, E. A., & Pexman, P. M. (2008). Eye gaze provides a window on children's understanding of verbal irony. *Journal of Cognition and Development*, *9*(3), 257–285.

Colich, N. L., Wang, A.-T., Rudie, J. D., Hernandez, L. M., Bookheimer, S. Y., & Dapretto, M. (2012). Atypical neural processing of ironic and sincere remarks in children and adolescent with autism spectrum disorders. *Metaphor and Symbol*, *27*(1), 70–92.

Currie, C. E., Elton, R. A., Todd, J., & Platt, S. (1997). Indicators of socioeconomic status for adolescents: The WHO Health Behaviour in School-aged Children Survey. *Health Education Research*, *12*(3), 385–397.

Deliens, G., Antoniou, K., Clin, E., Ostashchenko, E., & Kissine, M. (2018). Context, facial expression and prosody in irony processing. *Journal of Memory and Language*, *99*, 35–48.

de Villiers, J., Fine, J., Ginsberg, G., Vaccarella, L., & Szatmari, P. (2006). Brief report: A scale for rating conversational impairment in autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *37*(7), 1375–1380.

Filippova, E., & Astington, J. W. (2008). Further development in social reasoning revealed in discourse irony understanding. *Child Development*, *79*(1), 26–138.

Gerrig, R. J., & Goldvarg, Y. (2000). Additive effects in the perception of sarcasm: Situational disparity and echoic mention. *Metaphor and Symbol*, *15*(4), 197–208.

Geurts, H. M., Corbett, B., & Solomon, M. (2009). The paradox of cognitive flexibility in autism. *Trends in Cognitive Sciences*, *13*(2), 74–82.

Gibbs, R. W. (2002). A new look at literal meaning in understanding what is said and implicated. *Journal of Pragmatics*, *34*(4), 457–486.

Glucksberg, S., Gildea, P., & Bookin, H. B. (1982). On understanding nonliteral speech: Can people ignore metaphors? *Journal of Verbal Learning and Verbal Behavior*, *21*(1), 85–98.

Grice, H. P. (1975). Logic and conversation. In P. Cole & J. L. Morgan (Eds.), *Syntax and semantics: Speech acts* (pp. 41–58). New York: Academic Press.

Happé, F. G. E. (1993). Communicative competence and theory of mind in autism. A test of relevance theory. *Cognition*, *48*(2), 101–119.

Happé, F. G. E. (1995). The role of age and verbal ability in the theory of mind task performance of subjects with autism. *Child Development*, *66*(3), 843–855.

Heavey, L., Phillips, W., Baron-Cohen, S., & Rutter, M. (2000). The awkward moments test: A naturalistic measure of social understanding in autism. *Journal of Autism and Developmental Disorders*, *30*(3), 395–406.

Hermann, I., Haser, V., Van Elst, L., Ebert, D., Müller-Feldmeth, D., Riedel, A., et al. (2013). Automatic metaphor processing in adults with Asperger syndrome: A metaphor interference effect task. *European Archives of Psychiatry and Clinical Neuroscience*, *263*, S177–S187.

Hill, E. (2004). Executive dysfunction in autism. *Trends in Cognitive Sciences*, *8*(1), 26–32.

Jary, M., & Kissine, M. (2014). *Imperatives*. Cambridge: Cambridge University Press.

Joliffe, T., & Baron-Cohen, S. (1999). The strange story test: A replication with high-functioning adults with autism or Asperger syndrome. *Journal of Autism and Developmental Disorders*, *29*(5), 395–406.

Kaland, N., Moller-Nielsen, A., Callesen, K., Mortensen, E. L., Gottlieb, D., & Smith, L. (2002). A new 'advanced' test of Theory of Mind: Evidence from children and adolescents with Asperger syndrome. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *43*(4), 517–528.

Kim, S. H., Paul, R., Tager-Flusberg, H., Lord, C., Volkmar, F. R., Paul, R., et al. (2014). Language and communication in autism language and communication in autism. In F. R. Volkmar, R. Paul, S. J. Rogers, & K. A. Pelphrey (Eds.), *Handbook of autism and pervasive developmental disorders* (4th ed., pp. 230–262). Hoboken: Wiley.

Kissine, M. (2012). Pragmatics, cognitive flexibility and autism spectrum disorders. *Mind and Language*, *27*, 1–28.

Kissine, M. (2013). *From utterances to speech acts*. Cambridge: Cambridge University Press.

Kissine, M. (2016). Pragmatics as metacognitive control. *Frontiers in Psychology*, *6*, 2057.

Kissine, M., Cano-Chervel, J., Carlier, S., De Brabanter, P., Ducenne, L., Pairon, M.-C., et al. (2015). Children with autism understand indirect speech acts: Evidence from a semi-structured act-out task. *PLoS ONE*, *10*, e0142191.

Kissine, M., De Brabanter, P., & Leybaert, J. (2012). The interpretation of requests in children with autism: The effect of the sentence-type. *Autism*, *16*, 523–532.

Kowatch, K., Whalen, J. M., & Pexman, P. M. (2013). Irony comprehension in action: A new test of processing verbal irony. *Discourse Processes*, *50*, 301–315.

Kreuz, R. J. (2000). The production and processing of verbal irony. *Metaphor and Symbol*, *15*(1–2), 99–107.

Kreuz, R. J., & Link, K. E. (2002). Asymmetries in the use of verbal irony. *Journal of Language and Social Psychology*, *21*(2), 127–143.

Lai, C. L. E., Lau, Z., Lui, S. S. Y., Lok, E., Tam, V., Chan, Q., et al. (2017). Meta-analysis of neuropsychological measures of executive functioning in children and adolescents with high-functioning autism spectrum disorder. *Autism Research*, *10*(5), 911–939.

Landry, O., & Al-Taie, S. (2016). A meta-analysis of the wisconsin card sort task in autism. *Journal of Autism and Developmental Disorders*, *46*(4), 1220–1235.

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

Lenth, R. (2016). Least-squares means: The R package lsmeans. *Journal of Statistical Software*, *69*(1), 1–33.

Lord, C., Rutter, M., DiLavore, P., Risi, S., Gotham, K., & Bishop, S. (2012). *Autism diagnostic observation schedule (ADOS)* (2nd ed.). Los Angeles: Western Psychological Corporation.

Loukusa, S., Leinonen, E., Kuusikko, S., Jussila, K., Mattila, M.-L., Ryder, N., et al. (2006). Use of context in pragmatic language comprehension by children with Asperger syndrome or high-functioning autism. *Journal of Autism and Developmental Disorders*, *37*(6), 1049–1059.

MacKay, G., & Shaw, A. (2005). A comparative study of figurative language in children with autistic spectrum disorders. *Child Language Teaching and Therapy*, *20*(1), 13–32.

Martin, I., & McDonald, S. (2003). Weak coherence, no theory of mind, or executive dysfunction? Solving the puzzle of pragmatic language disorders. *Brain and Language*, *85*, 451–466.

Martin, I., & McDonald, S. (2004). An exploration of causes of non-literal language problems in individuals with Asperger syndrome. *Journal of Autism and Developmental Disorders*, *34*(3), 311–328.

Mary, A., Slama, H., Mousty, P., Massat, I., Capiau, T., Drabs, V., et al. (2016). Executive and attentional contributions to theory of mind deficit in attention deficit/hyperactivity disorder (ADHD). *Child Neuropsychology*, *22*(3), 345–365.

Monetta, L., & Champagne, M. (2004). Processuscognitifs sous jacents déterminant les troubles de la communication verbale chez les cérébrolésés droits. *Rééducation orthophonique*, *42*(219), 27–41.

Norbury, C. F. (2005). Barking up the wrong tree? Lexical ambiguity resolution in children with language impairments and autistic spectrum disorders. *Journal of Experimental Child Psychology*, *90*, 141–171.

Norbury, C. F. (2005). The relationship between theory of mind and metaphor: Evidence from children with language impairment and autistic spectrum disorder. *British Journal of Developmental Psychology*, *23*(3), 383–399.

Ozonoff, S. (1997). Components of executive function in autism and other disorders. In J. Russell (Ed.), *Autism as an executive disorder* (pp. 179–211). Oxford: Oxford University Press.

Ozonoff, S., & Miller, J. N. (1996). An exploration of right-hemisphere contributions to the pragmatic impairments of autism. *Brain and Language*, *52*, 411–434.

Ozonoff, S., Pennington, B. F., & Rogers, S. J. (1991). Executive function deficits in high-functioning autistic individuals: Relationship to theory of mind. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *32*(7), 1081–1105.

Ozonoff, S., South, M., & Provencal, S. (2005). Executive functions. In F. R. Volkmar, R. Paul, A. Klin, & D. Cohen (Eds.), *Handbook of autism and pervasive developmental disorders* (3rd ed., pp. 606–627). Hoboken: Wiley.

Paul, R., & Cohen, D. J. (1985). Comprehension of indirect requests in adults with autistic disorders and mental retardation. *Journal of Speech and Hearing Research*, *28*(4), 475–479.

Paul, R., Orlovski, S. M., Marcinko, H. C., & Volkmar, F. (2008). Conversational behaviors in youth with high-functioning ASD and Asperger syndrome. *Journal of Autism and Developmental Disorders*, *39*(1), 115–125.

Perkins, M. R. (2007). *Pragmatic impairment*. Cambridge: Cambridge University Press.

Perner, J., & Winner, E. (1985). "John thinks, that Mary thinks that…" attribution of second-order belief by 5- to 10-year-old children. *Journal of Child Experimental Psychology*, *39*, 437–471.

Persicke, A., Tarbox, J., Ranick, J., & St. Clair, M. (2013). Teaching children with autism to detect and respond to sarcasm. *Research in Autism Spectrum Disorders*, *71*, 193–198.

Pexman, P. M., Rostad, K. R., McMorris, C. A., Climie, E. A., Stowkowy, J., & Glenwright, M. R. (2011). Processing of ironic language in children with high-functioning autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *41*(8), 1097–1112.

Pijnacker, J., Hagoort, P., Buitelaar, J., Teunisse, J. P, & Geurts, B. (2009). Pragmatic inferences in high-functioning adults with autism and Asperger syndrome. *Journal of Autism and Developmental Disorders*, *39*, 607–618.

R Core Team. (2016). *R: A language and environment for statistical computing*. Vienna: R Foundation for Statistical Computing.

Recanati, F. (2004). *Literal meaning*. Cambridge: Cambridge University Press.

Russell, J., & Hughes, C. (1994). Evidence for executive dysfunction in autism. *Neuropsychologia*, *32*(4), 477–492.

Ruytenbeek, N., Ostashchenko, E., & Kissine, M. (2017). Indirect request processing, sentence-types and illocutionary forces. *Journal of Pragmatics*, *119*, 46–62.

Searle, J. R. (1975). Indirect speech acts. In P. Cole & J. L. Morgan (Eds.), *Syntax and semantics: Speech acts* (Vol. 3, pp. 59–82). New York: Academic Press.

Senju, A., Southgate, V., Miura, Y., Matsui, T., Hasegawa, T., Tojo, Y., et al. (2010). Absence of spontaneous action anticipation by false belief attribution in children with autism spectrum disorders. *Development and Psychopathology*, *22*, 353–360.

Shallice, T. (1982). Specific impairments of planning. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *298*(1089), 199–209.

Shintel, H., & Keysar, B. (2009). Less is more: A minimalist account of joint action in communication. *Topics in Cognitive Science*, *1*, 260–273.

Sperber, D., & Wilson, D. (2002). Pragmatics, modularity and mind-reading. *Mind and Language*, *17*, 3–23.

Surian, L., Baron-Cohen, S., & Van der Lely, H. (1996). Are children with autism deaf to Gricean maxims? *Cognitive Neuropsychiatry*, *1*(1), 55–71.

Wang, A. T., Lee, S. S., Sigman, M., & Dapretto, M. (2006). Neural basis of irony comprehension in children with autism: The role of prosody and context. *Brain*, *129*(4), 932–943.

Wearing, C. (2010). Autism, metaphor and Revelance theory. *Mind and Language*, *25*(2), 196–216.

Wechsler, D. (2008). *Wechsler Adult Intelligence Scale (WAIS-IV)* (4th ed., Vol. 22). San Antonio: NCS Pearson.

Yirmiya, N., Erel, O., Shaked, M., & Solomonica-Levi, D. (1998). Meta-analyses comparing theory of mind abilities of individuals with autism, individuals with mental retardation, and normally developing individuals. *Psychological Bulletin*, *124*(3), 283–307.

Zelazo, P. D., Jacques, S., Burack, J. A., & Frye, D. (2002). The relation between theory of mind and rule use: Evidence from persons with autism-spectrum disorders. *Infant and Child Development*, *11*, 171–195.