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Judgments of spoken discourse and impression formation of neurotypical and autistic adults

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ABSTRACT

Background: Studies on impression formation in Autism Spectrum Disorder (ASD) have suggested that both ASD and neurotypical (NT) individuals extract paralinguistic cues (e.g., vocal and facial expressions) from brief extracts of social behaviors to form less favorable impressions of the personality traits of ASD individuals than of their NT peers. Yet, discourse studies in ASD have also suggested that there are specific linguistic features (e.g., conjunctions) that can distinguish the speech of ASD individuals from that of NT individuals. This study investigates whether naïve participants with and without autism can perceive discourse features previously identified as characteristic of ASD speech, based on a single exposure to conversation extracts.
Methods: A cross-design rating experiment was created whereby a group of ASD and NT adults (blind to diagnosis information) rated audio recordings involving ASD and NT speakers. Rating participants evaluated the recordings using a Likert scale targeting impressions of discourse features.
Results: ASD and NT Raters behaved similarly on the ratings of discourse features; evaluating the speech of ASD Speakers less favorably than those of NT Speakers.
Conclusion: Our results extend previous findings by showing that linguistic cues also lead to less favorable impressions of the discourse of ASD Speakers, and this from both the perspective of NT and ASD Raters.

1. Introduction

Around 40 % of individuals with a diagnosis of Autism Spectrum Disorder (American Psychiatric Association, 2013) present a distinct behavioral presentation, recognizable within minutes; a phenomenon termed as 'frank' autism (de Marchena & Miller, 2017). As a first step to gain further insight into this construct, de Marchena and Miller (2017) asked clinicians - among other questions - which specific behaviors contribute to a frank presentation of ASD (de Marchena & Miller, 2017). The clinicians reported the following characteristics: a general sense of impaired reciprocal interactions, eye contact quality, atypical prosody, presence of motor

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mannerisms, and atypical walking or posture. Although social communication has not yet been investigated in detail in relation to frank autism, several linguistic features that are likely associated with an ASD-specific presentation emerge from previous discourse studies: reduced discourse coherence (e.g., Baixauli, Colomer, Rosello, & Miranda, 2016; de Villiers, 2011; Geelhand, Papastamou, Deliens, & Kissine, 2020), atypical use of referential expression (e.g., Colle, Baron-Cohen, Wheelwright, & Van Der Lely, 2008), pedantic style (e.g., De Villiers, Fine, Ginsberg, Vaccarella, & Szatmari, 2007; Ghaziuddin & Gerstein, 1996) and perseverance (e.g., De Villiers et al., 2007).

Importantly, the recognition of 'frank' features, viz. the recognition of a behavioral phenotype that leads to a rapid impression of ASD, is not limited to the trained observers in a clinical setting. 'Naïve', untrained observers also form rapid impressions of ASD individuals, which distinguish them from the impressions they form of their NT peers. Initially, studies on first impressions of naïve participants focused on the impressions of NT individuals. Based on brief extracts of social behavior and without knowing the protagonists' diagnostic status, NT raters appear to form an unfavorably skewed impression of the personal traits of ASD adolescents and adults, judging them as less attractive or more socially awkward than NT peers (Grossman, 2015; Sasson et al., 2017). Crucially, these less favorable impressions also lead to more reluctance to socially engage with autistic individuals (Sasson et al., 2017). This recent line of research contributes to the mounting evidence that the social difficulties experienced by ASD individuals might not only emerge from their own social communication difficulties, but also from negative biases and attitudes adopted by NT individuals. Two recent studies on impression formation also include the perspectives of individuals with a diagnosis of autism (DeBrabander et al., 2019; Grossman, Mertens, & Zane, 2019). Both studies suggest, maybe surprisingly, that ASD observers also form more negative impressions of the social skills (Grossman et al., 2019) and social presentation (DeBrabander et al., 2019; Grossman et al., 2019) of other ASD individuals than of NT individuals. However, the studies differed in their findings regarding subsequent behavioral intentions. In the study by Grossman et al. (2019), less favorable social perceptions were also associated with more reluctance to engage socially with autistic individuals for both groups of observers (NT and ASD) (Grossman et al., 2019). In contrast, in DeBrabander et al. (2019) less favorable impressions of social presentation was a barrier to subsequent social interactions only for NT observer, not for ASD observers; and this was regardless of diagnostic disclosure.

The unfavorable impressions of ASD individuals are based on audio (and video) recordings of social behaviors (e.g., Grossman, 2015; Sasson et al., 2017), suggesting that speech style essentially drives less favorable impressions of character traits such as social awkwardness. While this focus on the manner in which speech is delivered is in line with the frequent reports of an atypical prosody in ASD (Fusaroli, Lambrechts, Bang, Bowler, & Gaigg, 2017; Kissine & Geelhand, 2019; Kissine, Geelhand, De Foy, Harmegnies, & Deliens, 2021; McCann & Peppé, 2003), numerous studies on spoken discourse in ASD have also identified several linguistic features that distinguish the speech of ASD individuals from that of NT individuals. More specifically, discourse analyses indicate that the spoken discourse of ASD individuals is less coherent than that of their NT peers (for reviews see Baixauli et al., 2016; Stirling, Douglas, Leekam, & Carey, 2014). In a recent study, Geelhand et al. (2020) performed a systematic analysis of the linguistic features previously associated with three central dimensions of narrative discourse – the microstructure (syntactic complexity), macrostructure (overall story structure and cohesive ties) and internal state language – in pairwise matched groups of autistic (ASD) and neurotypical (NT) adults. While autistic adults did not lack the ability to create a story, they still performed worse than their NT peers on all three narrative dimensions. The features that emerged as specific to ASD adults were atypical use of connectives (e.g., *because*) and discourse markers (e.g., *well*), as well as irrelevant comments to the storyline. In line with the existing literature on narrative production in ASD, these results confirmed that ASD adults produce less coherent narratives than their NT peers, indicating persistent difficulties in narrative abilities well into adulthood. In brief, there is consistent evidence that specific linguistic features distinguish the speech of ASD from that of their NT peers. Of course, findings in clinical discourse analysis are based on detailed, time-consuming transcript analysis by a trained specialist. While such studies unveiled subtle speech patterns specific to autism it remains to be determined how relevant these linguistic differences may be beyond written transcripts.

A few studies have started to address this issue by complementing discourse analyses with judgments of naïve raters. For example, de Marchena and Eigsti (2010) examined speech-gesture synchrony of autistic and neurotypical adolescents during narrative retellings. They also recruited naïve raters (N = 10) to evaluate the quality (coherence and engagement) of the narrative retellings. Although the narratives of the two groups did not differ in gesture and speech frequency, narratives produced by autistic adolescents received lower ratings than those produced by their NT peers, suggesting that their narratives were harder to follow and less engaging. In a similar study, Morett, O'Hearn, Luna, and Ghuman (2016) investigated speech and gesture produced by autistic and neurotypical adolescents during a story retelling task in two different social contexts (non-visible vs. visible listener). The results suggest that both autistic and neurotypical adolescents produced more gestures and more speech in the presence of a visible than a non-visible listener. Morett and colleagues also asked naïve raters (N = 2) to evaluate the quality of the story retellings. Rating results suggest that communicative quality (coherence and engagement) also increased when there was a visible listener for neurotypical adolescents, but this was not the case for autistic adolescents. Interestingly, in both de Marchena and Eigsti (2010) and Morett et al. (2016), the ratings of narrative quality were associated with communicative and social symptoms in ASD. These two studies thus underscore the relevance of investigating first impressions triggered by the linguistic aspects of social communication in ASD.

A limitation of previous studies on impression formation lies in the content of the rated stimuli. Observers/listeners evaluated individuals holding a monologue, viz. individuals are recorded while presenting themselves for a mock TV audition (e.g. "High Risk Social Challenge" task; Gibson, Penn, Prinstein, Perkins, & Belger, 2010; Morrison, DeBrabander, Faso, & Sasson, 2019; Sasson et al., 2017; Sasson & Morrison, 2019) or retelling a story (de Marchena & Eigsti, 2010; Grossman et al., 2019; Morett et al., 2016). As such, stimuli participants were not rated in a social context, interacting with another person. Examining impression formation of speakers in more ecological contexts such as a dialogue remains an important gap in the literature. One study has begun to address this shortcoming and investigated the real-life implications of first impressions (Morrison et al., 2020). These authors collected first impressions

within the context of a 5-minute talk across three types of dyads: two same-diagnosis dyads (NT-NT & ASD-ASD) and one mixed-diagnosis dyad (NT-ASD). Dyad members were instructed to talk to one another with the goal of getting to know each other. Afterwards, they were instructed to evaluate their partner and the social interaction. Replicating previous findings with third-party observers, Morrison et al. (2020) found that ASD adults received less favorable ratings on certain traits (awkwardness, attractiveness and warmth) than did NT adults, by both ASD and NT partners. Perceptions of interaction quality did not differ for autistic and NT partners. Group differences surfaced in interest for future interactions: NT partners behaved similarly as in previous studies, reporting a greater interest for future interactions with NT partners than ASD partners. For ASD adults, there was a non-significant trend for a preference for future interactions with ASD partners. An important implication of the study is that both autistic and NT partners seem to be able to segregate their evaluations of personal traits from those of interaction quality, leading Morrison and colleagues to speculate that less favorable impressions of autistic adults are driven by personal characteristics rather than by the content of the interaction. However, Morrison and colleagues only focused on impressions of the overall quality of the interaction and did not investigate specific aspects of the interaction itself.

Taken together, the picture depicted so far by studies on impression formation in ASD is rather clear: when diagnosis status is withheld, ASD individuals receive more negative impressions from first- and third-party observers, with and without a diagnosis of ASD. Nevertheless, an important outstanding question is to determine whether specific linguistic cues (e.g., fluency, coherence) play a significant role in first impressions of ASD individuals and their discourse abilities.

The aim of the present study is to address this gap by investigating the perception of different discourse features by naïve raters. In this respect, our study distinguishes itself from previous studies that have also used audio recordings (e.g., Grossman, 2015; Sasson et al., 2017) as the first impressions we collected did not target character traits (e.g., social awkwardness, attractiveness) but the discourse abilities of the speakers in the audio recordings. Furthermore, we investigated impression formation from the perspective of both ASD and NT adults. As mentioned above, recent theories on the socio-communicative difficulties propose that ASD individuals experience social difficulties as a result of a bidirectional breakdown, as NT and ASD individuals have difficulties reading each other's minds (e.g., Milton, 2012). In an effort to account for the social dynamic of interactions, we asked whether ASD adults would attend to similar linguistic cues and interpret them in a similar fashion as NT adults.

Based on detailed analyses of verbal productions of ASD and NT adults (see Methods section for more details), we developed a scale of linguistic features to assess the audio recordings of conversational dyads between a participant with or without a diagnosis of autism and an experimenter. Two new groups of ASD adults and pairwise matched NT adults were recruited to rate these audio recordings. Based on the consistent findings that blind to diagnosis status, both ASD and NT individuals rate other ASD individuals less positively than their NT peers, we hypothesized that audio recordings with ASD speakers would receive lower ratings on all scale items than those with NT speakers by both ASD and NT participants.

2. Methods

This study received ethical clearance from the Ethics Committee of the Faculté des Sciences psycholgiques et de l'éducation (reference number 060/2017) at Université libre de Bruxelles. Written consent was obtained from all participants.

2.1. Participants

Participants included 36 French-speaking ASD and NT adults. Autistic participants (N = 18) were recruited via the *Autism in Context: Theory and Experiment* (ACTE) register of volunteers or by word of mouth. Participants in the comparison group were recruited via advertisements on the internet or by word of mouth. Inclusion criteria for both groups included: 1) age between 16 and 60 years, 2) a Full-Scale IQ (FIQ) score above 70, 3) Verbal IQ (VIQ) score above 70 and 4) normal or corrected-to-normal vision and audition. For the NT group (N = 18), there was the extra inclusion criterion of no known psychiatric, developmental or neurological disorder. Participants were matched individually on age and gender and were group matched on FIQ and VIQ.

ASD participants had all received a formal diagnosis of ASD from a multi-disciplinary team of accredited professional clinicians. If ADOS scores were not available for participants at the time of the study, Module 4 of the Autism Diagnostic Observation Schedule-2 (ADOS-2; Lord et al., 2012) was administered to these participants by two neuropsychologists, with a formal ADOS-2 accreditation. Furthermore, as advised by Baron-Cohen and colleagues, the Empathy Quotient (EQ; Baron-Cohen & Wheelwright, 2004) was administered along with the Autism Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001); these two scales provide an estimate of autistic-like traits presented by an individual, and allows for situating them on the continuum from autism to neurotypicality. Two participants who had received a formal diagnosis of autism did not meet the autism cut-off (> 7). None of the results reported below changed when these two participants were removed from the analyses. A multi-disciplinary assessment is a much more reliable diagnostic indication than the ADOS scores, and we decided to keep these two participants in the final analyses. Finally, the AQ scores of participants in the autism group were significantly higher than those of the participants in the comparison group (Cohen's d = 3.70, 95 % CI [2.62, 4.78]), while participants in the comparison group scored significantly higher on the EQ (Cohen's d = 1.50, 95 % CI [0.76, 2.24]). There was no age difference between the two groups.

Participants' Intelligence Quotient (IQ) was assessed using the full version of the Wechsler Adult Intelligence Scale (WAIS-IV;

Table 1
Descriptive statistics of rating participants' characteristics (ASD is the reference level).

	ASD (N = 18)	NT (N = 18)	t	df	p
Male : Female	10:8	10:8			
Age					
Mean (Standard Deviation)	31.39 (8.40)	31.33 (8.46)	0.02	34	.98
Range	*17.03–49.11*	*17.06-51.02*			
Total ADOS-2 Score					
Mean (Standard Deviation)	11.67 (5.01)	NA			
Range	*3–22*				
AQ					
Mean (Standard Deviation)	38.65 (4.14)	13.36 (5.44)	14.31	24	< .001
Range	*32–46*	*4–21*			
EQ					
Mean (Standard Deviation)	19.18 (7.58)	38.29 (10.19)	−5.81	23	<.001
Range	*6–37*	*26–61*			
FIQ (SD)					
Mean (Standard Deviation)	116.33 (14.32)	118.81 (12.54)	−0.54	32	.59
Range	*80–143*	*94–136*			
VIQ (SD)					
Mean (Standard Deviation)	121.71 (19.90)	124.12 (14.03)	−0.41	29	.69
Range	*77–150*	*96–139*			
PIQ (SD)					
Mean (Standard Deviation)	113.41(16.29)	108.12 (12.64)	1.05	30	.30
Range	*72–136*	*84–134*			

Table 2
Descriptive statistics (means and standard deviations in brackets) of the speakers in the audio recordings per diagnostic group (ASD is the reference level).

	ASD (N = 6)	NT (N = 6)	T	df	p
Male : Female	3:3	3:3			
Age					
Mean (Standard Deviation)	34.71(12.71)	36.56 (10.87)	−0.28	9.76	.792
Range	*20.00–52.09*	*20.10–52.01*			
Total ADOS-2 Score					
Mean (Standard Deviation)	11.67 (3.83)	1.17 (1.48)	6.35	6.19	.001
Range	7–16	0–3			
AQ					
Mean (Standard Deviation)	38.40 (9.29)	10.40 (4.67)	6.02	5.9	.001
Range	25–48	5–17			
EQ					
Mean (Standard Deviation)	25.00 (13.98)	47.40 (7.50)	−3.16	6.13	.019
Range	*9–44*	41–56			
FIQ					
Mean (Standard Deviation)	116.33 (11.81)	112.17 (8.28)	0.71	8.96	.5
Range	*100–132*	*99–121*			
VIQ					
Mean (Standard Deviation)	124.00 (10.53)	112.67 (10.41)	1.88	1	.09
Range	*110–137*	*100–122*			
PIQ					
Mean (Standard Deviation)	108.33 (15.31)	108.17 (8.21)	0.02	7.66	.99
Range	*82–122*	*94–118*			

Wechsler, 2008).[1] As can be seen from Table 1, ASD and NT participants did not differ in Full-scale IQ (FIQ), Verbal IQ (IQ) or Perceptual IQ (PIQ). Henceforth, the participants in this group will be referred to as "Rating participant" or "Raters".

2.2. Material & design

Experimental stimuli consisted of twelve audio extracts from Module 4 of the ADOS-2 obtained within the context of a larger research project on spoken discourse in autism (for a detailed explanation see Geelhand & Kissine, 2019). The audio recordings in this study concern more specifically the semi-structured questions on friendship, relationships and marriage as this task approximates

[1] The first author administered the WAIS-IV to the participants.

Table 3
Rating scale items.

	Item Question	Item Response
1	*With respect to the questions asked, the content of the responses is*	*Irrelevant 1 2 3 4 5 6 7 Relevant*
2	*Is it easy to follow the conversation?*	*Difficult 1 2 3 4 5 6 7 Easy*
3	*The structure of the answers seems*	*Illogical 1 2 3 4 5 6 7 Logical*
4	*With respect to the style of the questions asked, the type of information provided in the answers is*	*Inappropriate 1 2 3 4 5 6 7 Appropriate*
5	*The answers seem*	*Artificial 1 2 3 4 5 6 7 Natural*
6	*The answers are produced in a way that is*	*Choppy 1 2 3 4 5 6 7 Fluent*
7	*With respect to the different types of questions asked, the answers are*	*Repetitive 1 2 3 4 5 6 7 Varied*
8	*Is the person answering the questions similar to most people?*	*Not at all 1 2 3 4 5 6 7 A lot*

natural conversational situations. The full list of questions asked is located in Appendix A. The twelve recordings consisted of six experimenter-ASD dyads (three male ASD participants, three female ASD participants and six experimenter-NT dyads (three female NT participants, three male NT participants). Consent to use the audio recordings had been obtained from these twelve participants. To respect confidentiality, any identifying information was removed from the audio extracts. The length of the extracts was on average 407.17 s (SD = 98.38 s; range = 225–606 s).

Table 2 summarizes the characteristics of the ASD and NT participants in the dyads, i.e. of the speakers in the audio recordings. As can be seen, the ADOS-2 scores of the participants in the autism group were significantly higher than those of the participants in the comparison group (Cohen's d = 2.56, 95 % CI [1.03, 4.08]). Futhermore, as with the group of Raters, the AQ scores of participants in the autism group were significantly higher than those of the participants in the comparison group (Cohen's d = 2.70, 95 % CI [1.13, 4.26]), while participants in the comparison group scored significantly higher on the EQ (Cohen's d = 1.41, 95 % CI [0.15, 2.68]). There was also no age difference between the two groups as well as no groupe difference in FIQ, VIQ & PIQ. Henceforth, the participants of the audio recordings will be referred to as "Speakers".

While it could be argued that the topic of relationships is difficult to discuss for autistic individuals, which may negatively influence the ratings, any group differences we find could not solely be attributed to the topic of conversation as the scale items (see below) did not target the topic of the conversation (e.g., how well participants can talk about relationships) but how participants structured and delivered discourse content.

2.3. Rating scale

The items of the rating scale designed to evaluate the audio recordings are based on atypical features of autistic speech, identified through detailed discourse analysis in previous studies (see, Baixauli et al., 2016; De Villiers et al., 2007; Fine, Bartolucci, Szatmari, & Ginsberg, 1994; Geelhand et al., 2020; Ghaziuddin & Gerstein, 1996; Irvine, Eigsti, & Fein, 2016; Lake, Humphreys, & Cardy, 2011; Landa, 2000; Losh & Capps, 2003; Morett et al., 2016; Paul, Orlovski, Marcinko, & Volkmar, 2009; Stirling et al., 2014). Considering the novelty of the scale, it was first pretested. Of the initial 13 scale items, two were removed due to low internal consistency. Detailed results of the pretest can be found in Additional File 1. Another three items were administered during the study reported here, but removed from final analyses because their interpretation is not straightforward in the context of autism.[2] These items are presented in detail in Additional File 2.

Accordingly, eight scale items were included in the final analyses. Seven items targeted the content of the answers of the participants (1–7): relevance (item 1; Geelhand et al., 2020; Landa, 2000; Losh & Capps, 2003; Paul et al., 2009), referential cohesion (item 2; Colle et al., 2008; Fine et al., 1994; Geelhand et al., 2020), coherence (item 3; Baixauli et al., 2016; Geelhand et al., 2020; Stirling et al., 2014), pedantic style (item 4; (De Villiers et al., 2007; Ghaziuddin & Gerstein, 1996; Paul et al., 2009), rehearsed (item 5; Philofsky, Fidler, & Hepburn, 2007), fluency (item 6; Feldstein, Konstantareas, Oxman, & Webster, 1982; Geelhand et al., 2020; Irvine et al., 2016; Lake et al., 2011; Morett et al., 2016) and perseverance (item 7; De Villiers et al., 2007). To test whether participants noticed that some speakers were not neurotypical, we asked an additional question about speaker typicality (item 8). See Table 3 for a description of the scale items.

2.4. Procedure

Rating participants were either tested at the Université libre de Bruxelles or at their home, according to their preference. During the first session, participants' IQ was evaluated, and at the end of the session they were given questionnaires to fill in at home (EQ and AQ questionnaires). During the second session, rating participants performed two experimental tasks on a computer which are not part of this study. Finally, during the third session, rating participants performed the rating task. The rating task was implemented in LimeSurvey (Schmitz, 2012) and was self-paced. Rating participants performed the task on a laptop, using earphones. Before starting the rating task, rating participants were given time to familiarize themselves with the scale items with a practice item. Rating

[2] We thank one of our reviewers for highlighting this interpretation issue.

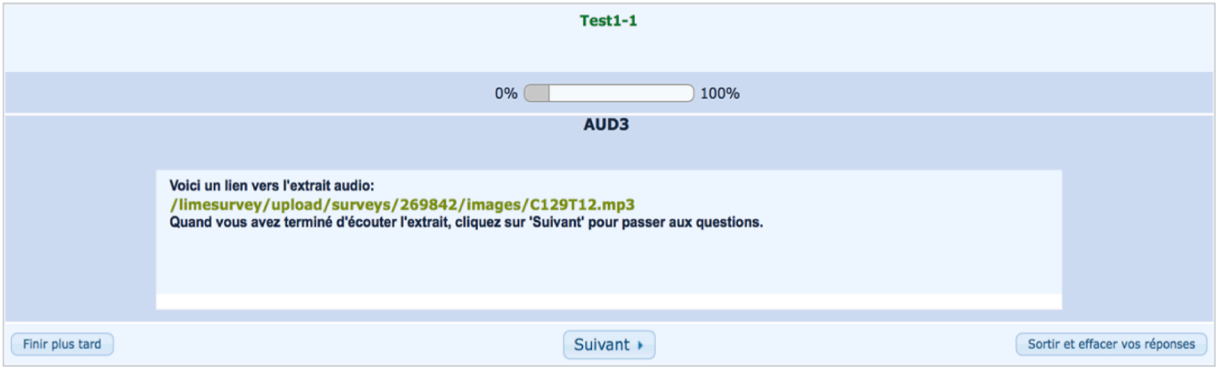

Fig. 1. Presentation of an audio recording in Limesurvey.

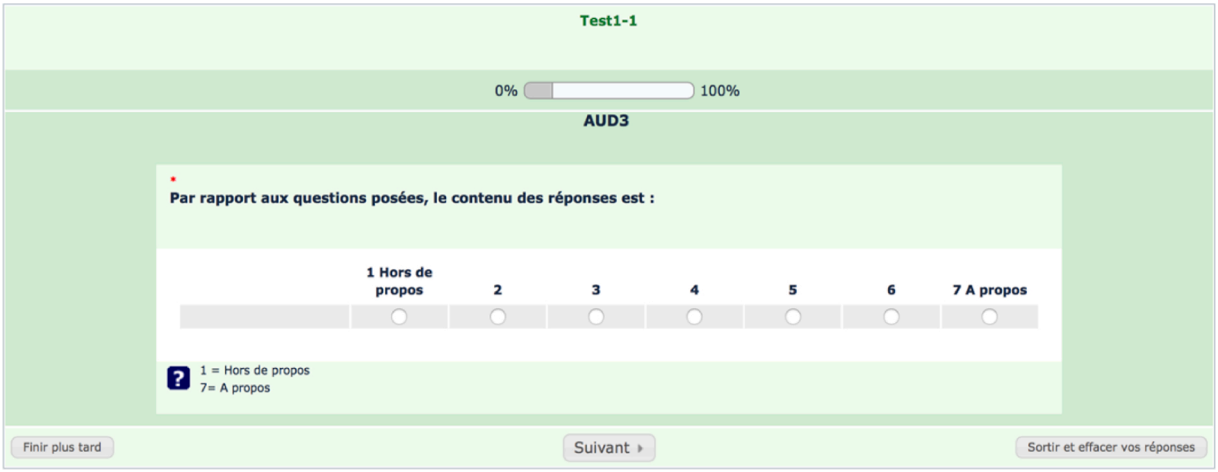

Fig. 2. Presentation of a rating item in Limesurvey.

participants were instructed that they would listen to two sequences of six audio recordings each, and that, after each audio, they would be asked to rate the speaker answering the questions of the experimenter. Audio recordings were presented without any visual input and were implemented as a link in Limesurvey which participants had to click on in order to listen to it (see Fig. 1). When participants finished listening to the audio recording, they clicked on the 'Next' button (*Suivant*) to access the rating scale (see Fig. 2). Each scale item was presented one by one. To keep rating participants blind to the diagnosis status of the speakers in the audio recordings, they were not given any information about the speakers.

2.5. Analysis

Since rating participants responded on a 7-point Likert-scale, the dependent variables (sum of rating scores) were ordered and are best analyzed with cumulative link regression models (as recommended, for instance, by Agresti, 2010). The effects of the diagnosis of the speakers in the audio recordings (henceforth Speaker diagnosis) on the ratings of the study participants' (henceforth Rater diagnosis) were analyzed with cumulative link models in R (R Core Team, 2016) using the **clm** function from the 'ordinal' package (Christensen, 2015). For each dependent variable (total rating score and scores of individual scale items) a model was created with Speaker diagnosis and Rater diagnosis entered as fixed effects. Significance of each fixed effect was assessed by performing likelihood ratio tests relative to a model without the effect at hand. When appropriate, interaction effects between diagnosis of Speaker and Rater were also tested (see Additional File 2). Post-hoc analyses were implemented with the **emmeans** function from the 'emmeans' package (Lenth, 2016). To support the robustness of our effects, see Appendix B for an estimation of effect sizes.

Table 4
Means and standard deviations (in brackets) rating scores of all scale items per Speaker and Rater diagnosis.

	Total Rating Score (SD)
ASD rater	
ASD speaker	4.88 (1.72)
NT speaker	5.27 (1.50)
NT rater	
ASD speaker	4.55 (1.72)
NT speaker	5.46 (1.45)

Table 5
Cumulative link model with additive effects of Speaker diagnosis and Rater diagnosis for individual scale items (ASD diagnosis is the reference level for all effects, standard errors are between brackets).

Rating Score	Speaker Diagnosis	Rater Diagnosis
Relevance (1)	0.88 (0.17)***	−0.16 (0.17)
Referential cohesion (2)	0.66 (0.17)***	−0.01 (0.17)
Coherence (3)	0.87 (0.17)***	−0.1 (0.17)
Pedantic style (4)	0.94 (0.17)***	−0.21 (0.17)
Rehearsed (5)	0.34 (0.17)*	0.05 (0.17)
Fluency (6)	0.61 (0.17)***	0.001 (0.17)
Perseverance (7)	0.44 (0.17)**	0.23 (0.17)
Speaker Typicality (8)	1.68 (0.18)***	−0.12 (0.17)

Signif. codes : 0 '***' 0.001 '**' 0.01 '*' 0.05.

Table 6
Means and standard deviations (in brackets) rating scores of all individual scale items per Speaker and Rater diagnosis.

	ASD Rater		NT Rater	
	ASD Speaker	NT Speaker	ASD Speaker	NT Speaker
Relevance (1)	5.06 (1.58)	5.61 (1.28)	4.66 (1.64)	5.68 (1.34)
Referential cohesion (2)	4.79 (1.73)	5.16 (1.52)	4.52 (1.65)	5.37 (1.53)
Coherence (3)	4.75 (1.59)	5.26 (1.25)	4.37 (1.61)	5.41 (1.38)
Pedantic style (4)	4.76 (1.70)	5.38 (1.30)	4.34 (1.62)	5.42 (1.40)
Rehearsed (5)	5.47 (1.29)	5.34 (1.65)	5.13 (1.65)	5.73 (1.36)
Fluency (6)	4.27 (1.61)	4.87 (1.54)	4.33 (1.53)	4.80 (1.62)
Perseverance (7)	4.79 (1.55)	5.08 (1.29)	4.86 (1.51)	5.37 (1.33)
Speaker Typicality (8)	3.27 (1.61)	4.78 (1.55)	3.14 (1.43)	4.65 (1.58)

3. Results

3.1. Full scale

To examine if there were overall differences in rating scores, we created a cumulative link model with total rating scores as dependent variable and the additive effects of Speaker and Rater diagnosis (ASD diagnosis is the reference level for all effects). There was a main effect of Speaker diagnosis on the overall ratings of the scale, $\beta = .70$, $\chi^2(1) = 136.57$, $p < .001$, but no effect of Rater diagnosis, $\beta = -.07$, $\chi^2(1) = 1.23$, $p = 0.27$). Overall, NT Speakers received higher ratings than ASD Speakers. See Table 4.

3.2. Individual scale items

There was a significant main effect of Speaker diagnosis for all scale items, with NT speakers receiving significantly higher ratings than ASD speakers. There was no main effect of Rater diagnosis. See Table 5.

See Table 6 for mean ratings per Speaker and Rater diagnosis. For a visual illustration of the results (diverging stacked bar charts) see Appendix C.

4. Discussion

The main goal of this study was to investigate whether naïve raters with and without an autism diagnosis would be sensitive to discourse features that have been previously identified as specific to ASD speech, based on a single exposure to a naturalistic conversation. Our results confirm our hypothesis that raters with and without a diagnosis of ASD would form less favorable impressions of

ASD individuals' discourse competence in comparison to their NT peers. These results advance our understanding in the field of spoken discourse and first impressions by identifying a set of linguistic features that successfully discriminates between the discourse of ASD and NT speakers in both groups of raters. In other words, the saliency of these linguistic features is not limited to researchers' analyses of linguistic production, as their effect emerges from simple exposure to audio recordings. Furthermore, our discourse scale items spanned both linguistic features related to discourse style (e.g., fluency) and structure (e.g., referential cohesion). In that sense, our results provide important preliminary evidence that both discourse *style* and discourse *structure* play a role in first impressions of ASD adults.

A particularly important aspect of these findings is that while the discourse quality of ASD speakers was rated rather positively (with no mean ratings below 4/7), the ratings of ASD speakers were still consistently lower than the ratings of NT speakers. That is, differences in the spoken discourse between ASD and NT speakers are readily perceived both by ASD and NT raters, but the scope of this difference is relatively reduced. Lining up with previous assumptions (Larkin, Hobson, Hobson, & Tolmie, 2017), it seems that the ASD speakers whose audio recordings we used have acquired the necessary tools to communicate but employed them in a somehow awkward or inconsistent way. Furthermore, this conclusion that there are small but readily perceived discourse differences, even in the speech of highly verbal autistic adults, suggests that first impressions may not be limited to individuals exponent of "frank autism"[3] .

Turning to individual scale items, the three lowest scores for ASD speakers (by both ASD and NT Raters) were given for *fluency*, *coherence* and *pedantic style*. Interestingly, a rating scale developed by De Villiers et al. (2007) also highlighted these speech characteristics as specific to ASD individuals (De Villiers et al., 2007). These authors developed a rating scale composed of five constructs related to the pragmatics of conversation: atypical intonation; semantic drift; terseness; pedantic speech; perseveration. Their results validated these constructs as independent from one another, as well as from other measures such as IQ (except terseness). Our study confirms that fluency, coherence and pedantic style play an important role in the impression formation of discourse competence.

Another important aspect of our data is that ASD Raters are as sensitive as NT Raters to the linguistic differences in the speech of ASD and NT adults and evaluated them similarly. Hence, it seems that ASD and NT adults share a similar knowledge of what constitutes discourse (in)coherence and (a)typicality. Interestingly, ASD and NT Raters also appeared to share a similar concept of what constitutes a typical social presentation. Indeed, ASD Raters judged ASD Speakers as atypical to a similar degree as NT Raters, and NT Speakers' typicality was rated similarly by ASD and NT Raters.

All in all, the ASD and NT Raters in our study seem to share similar norms regarding spoken discourse and "auditory" social presentation. Interestingly, the cognitive and verbal profile of the Raters and Speakers were very comparable (see Tables 1 & 2). Yet, even though ASD Raters were able to pick up on cues that distinguish the speech of ASD Speakers from their NT peers, it is likely that these differences may emerge in their own discourse. While our study provides quite solid preliminary evidence in this direction, future studies are clearly needed to gain more insight into this apparent discrepancy between perception and production in ASD. Finally, our results are consistent with previous studies that reported that naïve raters can pick up on subtle cues in the presentation of autistic individuals. Future research could compare impressions of naïve raters with those of experts, such as clinicians and specialized educators.

4.1. Implications

Collectively with previous studies on first impressions of ASD individuals, the results of this study provide a glimpse into the real-life implications of linguistic differences in spoken discourse. Specifically, for individuals who have autism symptoms but cognitive and verbal abilities within or above the average range, autism can be a "hidden disability" (e.g., Portway & Johnson, 2005; Shtayermman, 2009). Although these individuals do not have obvious communication difficulties, subtle linguistic differences could ultimately lead to more negative attitudes and behaviors towards them.

At the professional level, differences in communication abilities can have high implications. For example, compared to other disability groups (mental retardation, learning disabilities and speech impairments), autistic individuals are less likely to find employment (Shattuck et al., 2012). Communication difficulties are one of the barriers they face when searching for a job, even when they have adequate competence for the advertised position (e.g., Hendricks, 2010). Arguably, adequate communication skills and good first impression at a job interview are key to securing the job. Hence, ASD individuals are likely to be put at disadvantage by a communication style that triggers less favorable impressions (in NT communication partners). Our results provide food for thought on what these communicative barriers may be and highlight the aspects of communication that may be the most problematic (e.g., fluency, coherence and pedantic style). Considering the potential personal and professional challenges that can arise from differences in communication abilities, it is important to both 1) raise awareness that differences in spoken discourse can lead to less favorable impressions and 2) provide support to ASD individuals to help them improve their communication efficiency.

The present study has several limitations which call for additional research to be undertaken. First, the topic of the rated conversation excerpt—friendships and relationships—might have induced a potential confound. Future studies should investigate

[3] We thank one of our reviewers for this suggestion.

impression formation across different conversation topics to better understand the influence of speech content on first impressions. In addition, comparing first impressions across different conversation topics can yield a better understanding of the role of conversational topics and their possible interaction with discourse structure and style. For example, it could be asked whether first impressions of the discourse abilities of autistic individuals improve (or, on the contrary, deteriorate) when they are talking about a topic of interest. Based on the findings by Nadig, Lee, Singh, Bosshart, and Ozonoff (2010) on the influence of topic on verbal exchange and gaze pattern, one may speculate that the conversation topic would not affect first impressions homogeneously: when talking about a topic of their specific interest, autistic speakers may become more fluent, but also come across as more pedantic. Likewise, to better determine whether style or substance of spoken discourse drives less favorable impressions of ASD individuals, future studies should directly compare first impressions of audio recordings and verbatim transcripts of the same recording.

Second, in the present study, raters evaluated a small sample of dyadic conversations and future studies should investigate a bigger sample of speakers to replicate the findings of the present study. Furthermore, the rated autistic speakers all had a high verbal IQ, limiting the generalizability of our findings to individuals on the spectrum with significant language and/or intellectual impairments. Third, our data does not allow us to conclude that impressions of discourse abilities directly contributed to speaker impressions. We hope, nonetheless, that this paper would provide impetus to future studies aiming at uncovering the causal relations (via mediation analysis for example) between specific discourse abilities and first impressions. Fourth, although the stimuli used in our study present a step forward towards more naturalistic and ecologically valid stimuli as they included a dialogue rather than a monologue (as was the case in previous studies), first impressions were obtained from third-party observers. Therefore, an important outstanding issue is the investigation of 'first-hand' impressions, viz. first impressions of individuals directly involved in the interaction (Morrison et al., 2020).

Notwithstanding these limitations, this study is the first to examine first impressions of linguistic characteristics in the speech of a well-matched group of ASD and NT adults. Furthermore, our findings are in line with previous studies on impression formation of ASD and NT individuals, but also provide novel evidence that linguistic cues in speech can contribute to the less favorable impressions of ASD speakers, and this both from the perspective of NT and ASD raters.

CRediT authorship contribution statement

Philippine Geelhand: Conceptualization, Methodology, Investigation, Formal analysis, Data curation, Project administration, Writing - original draft, Writing - review & editing. **Fanny Papastamou:** Investigation, Writing - review & editing. **Gaétane Deliens:** Investigation, Writing - review & editing. **Mikhail Kissine:** Validation, Formal analysis, Supervision, Funding acquisition, Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

Semi-structured interview questions: Friendships, Relationships and Marriage and Solitude

Following the ADOS-2 guidelines of this task, the experimenter asked about the participant's understanding of and opinion on the topics of friendship, relationship and marriage. Table A1 summarizes the different questions.

Table A1
ADOS-2 interview questions of the task *Friendship, Relationships and Marriage* .

Friendship, Relationships and Marriage
Do you have friends? Can you tell me more about them?
What do you like to do together? How did you meet them? How often do you see each other?
What does it mean for you "to be friends"?
How do you know a person is your friend?
How do you distinguish between a friend and someone you only work with or go to school with?
Do you have a girlfriend/boyfriend? What is his/her name? How old is he/she?
When did you last see him/her?
What is s/he like? What do you like doing together?
How do you know he/she is your boyfriend/girlfriend?
Where do you want to live when you are older? In what kind of accommodation (apartment, house, shared house)?
Who would you like to live with? Your family? Roommates? Alone?
Have you ever thought of having a long-term relationship, getting married (when you are older)?
Why do you think some people get married or live with their partner when they grow up?
In what ways is that a good thing? What could be difficult in being married or living with one's partner? Or living with roommates?

Appendix B

Effect size and power estimation

To estimate the robustness of our findings, we compared the effect sizes of our study with those of the study by Grossman et al. (2019), whose design is the closest to ours (2 stimulus participant (ASD-NT) X 2 rating participant (ASD-NT)). Grossman et al. (2019) report a significant main effect of stimulus diagnosis, suggesting that ASD individuals received lower ratings than NT individuals, by both ASD and NT Raters, which is also a crucial result of our paper. Grossman et al. (2019) do not report the effect sizes of their ANOVAs. Therefore, as a first step, we calculated the effect size of Grossman et al.'s (2019) main effect of stimulus diagnosis. The effect size of their main effect of stimulus diagnosis was large (Cohen's f = 0.7), accordingly achieved power was also high (0.99). Once this basis for comparison had been established, we used the function pwr.anova.test to determine the effect size we would need to achieve 0.8 power with our sample size (N = 36). The output of this function suggests we need an effect size of 0.33 to achieve 0.8 power. Finally, we converted the regression coefficients of our cumulative logistic models to Cohen's f to confirm the strength of our effects of speaker diagnosis. The outputs of this conversion are displayed in Table B1 below. All but one rating item (Rehearsed) has an effect size above 0.33, allowing us to conclude that, relative to previously published results, we have achieved sufficient power with our sample size.

Table B1
Effect sizes of the main effect of speaker diagnosis.

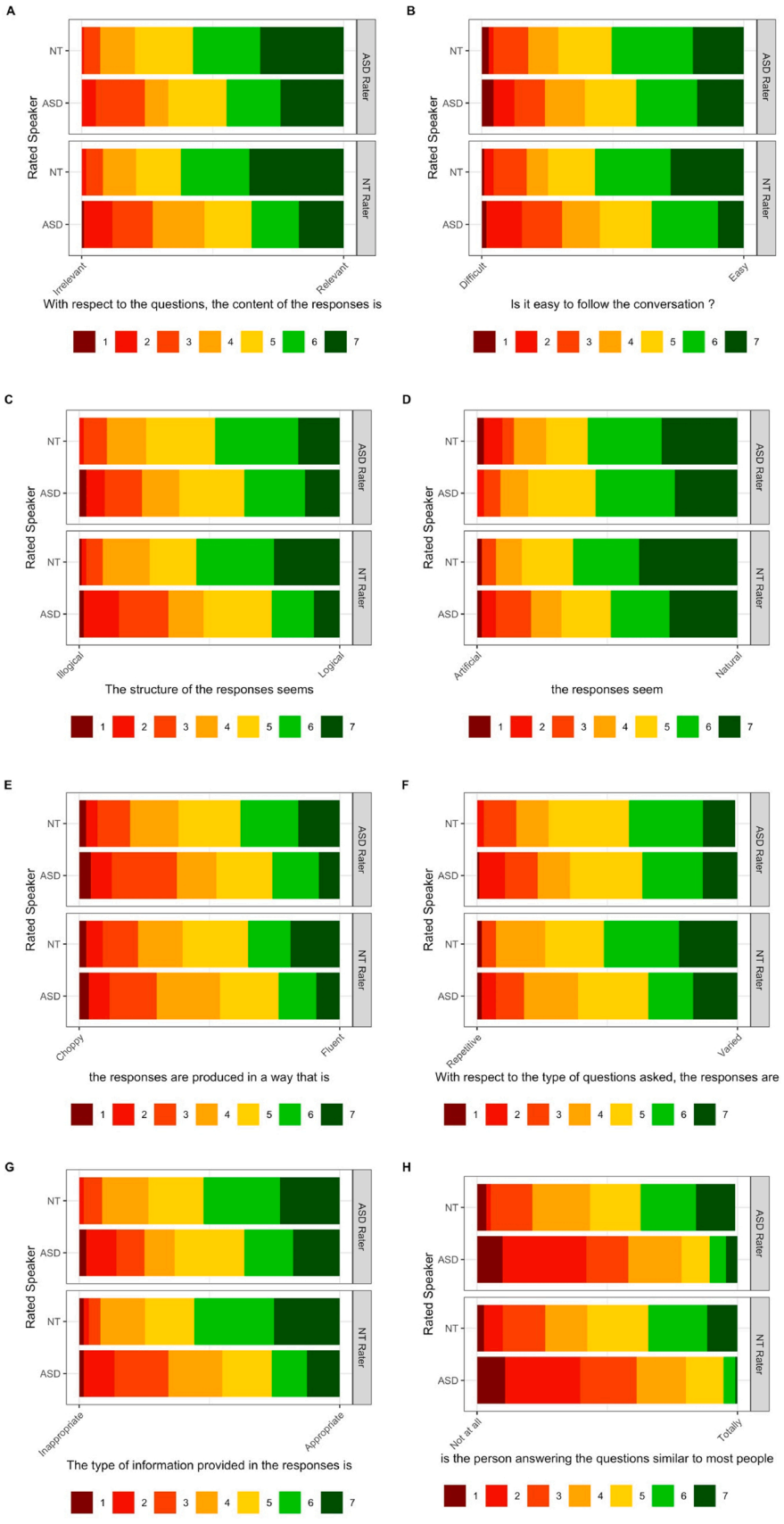
	Cohen's f	Lower CI	Upper CI
Relevance (1)	0.67	−0.06	1.39
Referential cohesion (2)	0.50	−0.20	1.19
Coherence (3)	0.66	−0.06	1.38
Pedantic style (4)	0.77	0.02	1.51
Rehearsed (5)	0.20	−0.46	0.86
Fluency (6)	0.43	−0.25	1.02
Perseverance (7)	0.35	−0.32	1.02
Speaker Typicality (8)	1.29	0.40	4.93

Appendix C

Diverging stacked bar charts of ratings

Diverging stacked bar charts were used to represent the ratings given by autistic and neurotypical participants (i.e., the raters) on the audios of autistic and neurotypical speakers (i.e., the "rated"). In diverging stacked bar charts, the responses are positioned horizontally so that positive responses are stacked on the right and negative responses are stacked left from this baseline.

Fig. C1 represents the ratings for the eight scale items: relevance (plot A), referential cohesion (plot B), coherence (plot C), rehearsed (plot D), fluency (E), perseverance (F), pedantic style (G) and speaker typicality (plot H)



(caption on next page)

Fig. C1. Diverging stacked bar charts representing the ratings of the speakers (by the raters) for the eight scale items. .

Appendix D. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.rasd.2021.101742.

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