Conversational Correlates of Rapid Social Judgments
of Children and Adolescents with and without ASD

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Abstract: Autism spectrum disorder (ASD) is characterized by deficits in social communication, and even children with ASD with preserved language are often perceived as socially awkward. We ask if linguistic patterns are associated with social perceptions of speakers. Twenty-one adolescents with ASD participated in conversations with an adult; each conversation was then rated for the social dimensions of likability, outgoingness, social skilfulness, responsiveness, and fluency. Conversations were analysed for responses to questions, pauses, and acoustic variables. Wide intonation ranges and more pauses within children's own conversational turn were predictors of more positive social ratings while failure to respond to one's conversational partner, faster syllable rate, and smaller quantity of speech were negative predictors of social perceptions.

Conversational Correlates of Rapid Social Judgments of Children and Adolescents with ASD

Though the language of children with autism spectrum disorder (ASD) is often impaired (Tager-Flusberg, Paul, & Lord, 2005), even children with fluent language and unimpaired cognitive skills exhibit atypicalities that can lead to impaired conversational flow. Studies on the speech production and conversational skills of children with ASD who have language and cognitive skills in the normal range have focused on a number of differences that distinguish the speech patterns of children with ASD, particularly in the realm of prosody (McCann & Peppé, 2003; Paul, et al., 2005; Shriberg et al., 2001), but have not yet systematically investigated the specific influence of prevalent prosodic features on how individuals with ASD are perceived by others. The aim of this paper is to explore the relationship between speaking pitch, rate, and rhythm and the resulting social perception of adolescents with ASD.

Acoustic analyses reveal that children with ASD exhibit increased variability in fundamental frequency (Bone, et al., 2016; Bone et al., 2013; Diehl, et al., 2009; Hubbard & Trauner, 2007; Kiss, 2017; Sharda et al., 2010), and their prosody is consistently rated as qualitatively poorer than neurotypical (NT) children on standardized prosody assessments (McAlpine, 2012; Peppé et al., 2006; Peppé, et al., 2007; Shriberg et al., 2001). In addition, analyses of conversational behaviour have demonstrated that children with ASD respond to questions less often than TD peers at the same developmental stage (Capps et al. 1998) and ignore or incompletely respond to family members' questions 25% of the time (Kremer-Sadlik 2004). This lack of conversational responsiveness results in atypical pausing in this population, particularly at moments when one speaker's turn ends and the other should begin speaking

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(Thurber & Tager-Flusberg 1993). Ochs et al. (2004) found that children with ASD may take longer than 1 second to respond to a question, while NT children respond with minimal gap (Sacks, et al., 1974) or a short pause of less than 1 second (Jefferson, 1986). More recently, Heeman et al. (2010) found that young children with ASD paused 27% longer than age-matched NT peers both when answering questions and when responding to non-questions. There is also evidence that individuals with ASD have atypical pauses when producing noun-phrases, such as "hot dog" (Grossman et al. 2010), indicating that atypical pausing behaviour in individuals with ASD occurs not only at turn-taking points, but also within their own productions. These data indicate that individuals with ASD who have otherwise strong structural language skills nevertheless struggle producing typical rhythm, rate, and intonation patterns of spoken language.

Given that listeners form lasting impressions of a speaker's personality, social status and skill based on very brief exposures (Bauman 2013), the question arises how these speech production differences of children with ASD influence their social perceptions by others. Evidence shows that exposures to audio recordings of adolescents with ASD as brief as one second lead to negative evaluations by adults naive to diagnosis during a story retelling task where language content is controlled and therefore not a possible driver of this negative perception (Grossman 2015). Sasson et al. (2017) further investigated the impact of language content versus speech production, and found that individuals with ASD were evaluated similarly to their TD peers based on transcripts of free speech samples, but rated more negatively based on audio recordings of their speech. There is also evidence that increased pitch variability among individuals with ASD leads to negative perceptions of their voices (Nadig & Shaw 2012, Diehl et al. 2009) and Shriberg et al (2001) suggest that speech that is too high-pitched can lead to an impression of being overbearing, while speech that is too slow can lead to a sense that the

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speaker is condescending. These data clearly show that the mechanics of speech production, including pitch range, speaking rate, and pauses can drive negative perceptual judgments of naive listeners and that these negative perceptions may be more related to individual speech patterns than overall language abilities. However, there have been no specific investigations to date of how each of these salient prosodic features drive perceptual judgments by individuals naive to diagnosis.

In this exploratory study, we use short audio recordings extracted from conversations of children and adolescents with ASD to elicit social judgments by large numbers of respondents. We hypothesize that individual variations in fundamental frequency, speaking rate, and pausing behaviour will drive negative social perceptions for individuals with ASD despite overall similar profiles of structural language ability, cognitive skills, and ASD symptomatology.

Method

Participants

Twenty-one children and adolescents with ASD (two females) participated in the study. ASD diagnosis was confirmed for all children via the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 1989)[1] conducted by a research-reliable administrator. Mean chronological age, non-verbal intelligence as indicated by performance on the Leiter International Performance Scale-Revised (Leiter-R; Roid & Miller, 1997), receptive English vocabulary as indicated by performance on the Peabody Picture Vocabulary Test (PPVT; Dunn & Dunn, 2007) scores, and ASD symptomatology as indicated by the Childhood Autism Rating Scale, Second Edition (CARS-2; Schopler, et al., 2010) are reported in Table 1.

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[1] The first edition of the ADOS was used because data were collected prior to the revision of the ADOS in 2012.

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[INSERT TABLE 1 ABOUT HERE]

Procedure

Participants were audio-recorded engaging in a brief conversation with an adult research assistant. The research assistant asked a series of open-ended questions in the format of a casual conversation at the end of a sequence of research tasks. One question pertained to a topic of interest, such as "Your mom told me you're really interested in animals. Can you tell me about that?" and one question aimed to elicit an emotional response, such as "Can you tell me about something that grosses you out?" We expected that this question would elicit an emotional response in both NT children and those with ASD, as there is increasing evidence in the literature that children with ASD produce emotional responses (such as laughter, vocalizations, and facial expressions) at an even higher rate or higher intensity level than NT children (Faso, et al., 2015; Grossman, et al., 2013; Zane, et al., 2017). The research assistant provided normal back-channel cues to sustain the conversation (e.g., "mm-hm") and allowed the child the opportunity to answer the questions posed before asking follow-up questions. If, however, children did not respond to the initial question, the research assistant would encourage the child to respond by reformulating the question or asking another question. Conversations lasted an average of 3 minutes 34 seconds each; children produced an average of 62.3 utterances (SD 47.0, range 22-209) and 274.4 words (SD 275.5, range 28-1025). For the 30-second clips rated for perceived social skills, children produced an average of 8.67 utterances (SD 2.85, range 5-17) and 35.95 words (SD 18.18, range 9-68), and responded to an average of 3.52 questions (SD 1.72, range 1-8).

Coding

All language produced by the participant and the adult conversation partner was transcribed using ELAN coding software. Research assistants trained in the coding protocol performed the first pass of coding. That coding was then verified and corrected if necessary by the first author, a linguist with experience coding language samples in ELAN.

Pauses

Periods of silence greater than 200 ms were coded as pauses, following Levinson and Torreira's (2015) definition of normal gaps in conversational turns. Pauses were categorized as interpersonal pauses (silence between speakers' conversational turns), intrapersonal pauses (silence within a speaker's utterance), or no-responses (silence following a question by the adult meant to elicit an answer, followed by another utterance by the adult). Interpersonal pauses were attributed to the second speaker, i.e. to the speaker about to start their conversational turn.

Acoustic variables

We calculated four acoustically-derived variables of the children's speech samples using Praat software. We computed median fundamental frequency (f_0), robust range of f_0 (i.e., the 95% quantile minus the 5% quantile), median syllable rate (syllables/s), and number of syllables produced. Syllable boundaries were determined by force-aligning the textual transcript with audio using SailAlign (Katsamanis, et al., 2011).

Ratings

We utilized Amazon's Mechanical Turk (MTurk), an online marketplace of workers, to obtain ratings of participants' social skills. We used a thin-slices methodology (Ambady, 2010; Ambady, et al., 1999; Ambady & Rosenthal, 1992, 1993; Rule & Ambady, 2009; Slepian, et al., 2014) to obtain rapid judgments about participants' social skills in the following five areas: *likability, outgoingness, social skilfulness, responsiveness*, and *fluency*. These five constructs

were chosen to measure affective response to the speaker (*likability*), judgments about the speaker's temperament (*outgoingness*) and social ability (*social skilfulness*), timeliness and quantity of responses (*responsiveness*), and rate and rhythm of speech (*fluency*). Previous studies using thin-slice ratings have demonstrated that even segments as brief as 1-3 seconds can suffice to provide significantly different ratings for individuals with and without ASD (e.g., Grossman 2015; Sasson, et al., 2017). The first 30 seconds of each conversation were rated by English-speaking MTurk workers using a non-graduated slider bar tool. We chose a non-graduated slider rather than a Likert scale to allow maximum freedom of judgment for participants; research has found that there are no significant differences between the two tools in web-based research (Roster, et al., 2015). All listeners were blind to diagnosis, were not informed of the larger context of the research, and were asked to respond to the following questions:

1. How likable did the child seem to you?

unlikable ——————————————————————————————— likable

2. How outgoing did the child seem to you?

reserved/shy ——————————————————————————————outgoing

3. How socially skilled did the child seem to you?

awkward ——————————————————————————————socially skilled

4. How responsive to the conversational partner did the child seem to you?

unresponsive ——————————————————————————————responsive

5. How fluent or smooth did the child's speech seem to you?

halting ——————————————————————————————fluent/smooth

448 mTurk workers (213 females; 47.54%) participated in the study. All raters were native speakers of American English and resided in the United States. Each conversational

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segment was rated by at least 70 mTurk workers ($M = 72.9$, SD = 1.2, range=70-76). The raters

in our sample had a mean age of 34.31 years (SD = 11.10, range 19-71) and belonged to the

following racial and ethnic groups: non-Hispanic white/Caucasian (322; 71.88%), African-

American or black (42; 9.38%), Asian (36; 8.04%), Hispanic (20; 4.46%), Hawaiian or Pacific

Islander (1; 0.22%), and mixed race or other (27; 6.03%). The highest level of education attained

by the raters was: middle school (0.89%), high school diploma (30.36%), two-year college

degree (23.44%), four-year college degree (35.94%), and post-graduate degree (9.38%).

Statistical approach

We employed a regression approach to study the relationship between ratings and characteristics

of conversation. Because the number of variables studied was larger than the number of

participants, a traditional regression analysis could not be conducted. We applied three

regularization methods to solve this problem: the least absolute shrinkage and selection operator

or LASSO (Tibshirani, 1996), the smoothly clipped absolute deviation or SCAD (Fan & Li,

2001), and the minimax concave penalty or MCP (Zhang, 2010). Each of these methods serves to

select those variables which are likely to be predictors by shrinking coefficients toward zero in

addition to setting some coefficients exactly equal to zero (thereby selecting the remaining

variables). After the three regularization methods selected the important variables, thus reducing

the number of predictors to fewer than the number of participants, the selected variables were

combined together to fit a traditional linear regression model. Based on this model, backward

selection was used to select a better model, producing only significant predictors.

Results

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Since raters only listened to the first 30 seconds of each conversation, all of the analyses that follow pertain to the first 30 seconds of each conversation only. The distribution of social ratings for the five dimensions are presented in Figure 1.

[INSERT FIGURE 1 ABOUT HERE]

Relationship Between Ratings, Language, and Other Characteristics

Likability

Likability ratings were significantly positively predicted by the number of intraspeaker pauses and negatively predicted by the total length of no-responses and chronological age; see Table 2. More than half of the variance in likability ratings was accounted for by these three variables; adjusted $R^2 = 0.64$.

[INSERT TABLE 2 ABOUT HERE]

Outgoingness

Outgoing ratings were significantly positively predicted by the robust range of f_0 and number of intraspeaker pauses. Outgoing ratings were significantly negatively predicted by median syllable rate and the overall pause-to-speech ratio. Nearly 90% of the variance in outgoing ratings was accounted for by a combined model of these variables; adjusted $R^2 = 0.87$; see Table 3.

[INSERT TABLE 3 ABOUT HERE]

Social skilfulness

Social skilfulness ratings were significantly positively related to robust range of f_0 and number of intraspeaker pauses, while being significantly negatively related to the total length of no-responses and the pause-to-speech ratio; adjusted R^2 for the combined model = 0.75; see Table 4.

[INSERT TABLE 4 ABOUT HERE]

Responsiveness

Responsiveness ratings were significantly positively predicted by number of intraspeaker pauses, while being significantly negatively predicted by median syllable rate and the pause-to-speech ratio; adjusted R^2 of the combined model = 0.82; see Table 5.

[INSERT TABLE 5 ABOUT HERE]

Fluency

Fluency ratings were significantly negatively predicted by the total length of interspeaker pauses and no-responses; adjusted R^2 of the combined model = 0.58; see Table 6.

[INSERT TABLE 6 ABOUT HERE]

Overall social skills

We summed up the scores of the five social dimensions to yield a total social skills score. Total social skills were significantly positively predicted by the robust range of f_0 and number of intraspeaker pauses while being significantly negatively predicted by the pause-to-speech ratio, the total length of no-responses, and median syllable rate. These variables accounted for 80% of the variance in ratings; R^2 of the combined model = 0.80 (Table 7).

[INSERT TABLE 7 ABOUT HERE]

Discussion

We found that several variables were both positive and negative predictors of perceived social communication ratings in adolescents with ASD. The most consistent predictor of positive evaluations of social communication behaviour was the robust range of fundamental frequency (f_0, predictive of positive ratings of outgoingness, social skilfulness, and overall combined ratings) and the number of intraspeaker pauses (predictive of likability, outgoingness, social skilfulness, responsiveness, and overall combined ratings. Thus, the wider the range of the child's intonation (represented by robust range of f_0), the more positively that child's social

communication behaviours were rated. This finding suggests that using a wide range of pitch during conversation is evaluated positively, while a conversational style that is more monotonous is evaluated negatively. Many prior studies have found that individuals with ASD show increased pitch variability (Diehl et al, 2009; Fosnot & Jun, 1999; Green & Tobin, 2009; Nadig & Shaw, 2012; Sharda et al., 2010), and some of these have also found that these speech samples are rated as more abnormal than samples produced by NT individuals (Nadig & Shaw, 2012). Our study adds to these works by demonstrating that such pitch variability is not necessarily rated negatively; indeed, speakers who employed a wider range of f_0 were rated as more outgoing and socially skilled than speakers whose f_0 range was narrower. What is unclear from this study, however, is whether this is due to some speakers with ASD producing relatively monotonous speech samples, which were then rated more negatively than speakers who produced samples with varied intonational ranges. Since we do not compare these speakers to NT speakers, we cannot know if the pitch ranges produced by these speakers with ASD would be more or less positively evaluated than those produced by NT speakers.

The most consistent predictors of negative social evaluations were the total length of no-responses (a negative predictor of likability, social skilfulness, fluency, and overall combined ratings), the pause-to-speech ratio (a negative predictor of outgoingness, social skilfulness, responsiveness, and overall combined ratings), and median syllable rate (a negative predictor of outgoingness, responsiveness, and overall combined ratings). Thus, the longer a child failed to respond to an interlocutor's question (total length of no-responses), the more a child paused in relation to the quantity of speech they produced (represented by the pause-to-speech ratio), and the faster that they spoke, the more negatively were the resulting social behaviour ratings. Thus, while pauses during the speaker's conversational turn (intraspeaker pauses) were positive

predictors of social ratings, failure to respond following an interlocutor's question was a negative predictor of social ratings. Listeners are thus sensitive to the timing and distribution of silence during conversation, and do not penalize speakers *per se* for pausing, provided that the pauses occur within a speaker's turn and do not follow an interlocutor's question.

With regard to the negative prediction power of the pause-to-speech ratio, it appears that raters were sensitive to the quantity of speech that participants produced. Thus, while it is acceptable to pause within one's conversational turn, it is only positively evaluated if the speaker also produces an acceptable quantity of speech in relation to those pauses. Excessive pausing with little speech is negatively perceived, while frequent pausing with abundant speech is judged positively.

Finally, raters were sensitive to the rate of speech, and penalized speakers for speaking too quickly. Median syllable rate was a negative predictor of outgoingness, responsiveness, and overall combined ratings. This result suggests that children who spoke quickly during conversation were evaluated more negatively than those who spoke more slowly. Shriberg et al (2001) found that speech that is too slow can lead to a sense that the speaker is condescending; we add to this result by demonstrating that speech that is too fast can also lead to negative evaluations. This finding also could be related to our finding of a positive relationship between intraspeaker pauses and social perceptions: pausing within one's conversational turn is a natural part of conversation, and failing to pause can result in speech that is perceived as too fast or hurried.

Two other variables were predictors of just one social dimension: total length of interspeaker pauses was a negative predictor of fluency, and chronological age was a negative predictor of likability. It appears, then, that raters penalized speakers who paused for longer

periods of time following their conversation partner's turn (but only on the fluency dimension), and that younger children were judged more likable than older children.

These results suggest that listeners were sensitive to a number of factors in evaluating the social skills of speakers. They were attentive to prosodic factors, such as robust range of f_0 and median syllable rate. Perhaps most suggestively, listeners were sensitive to the timing of pauses. Crucially, the number of pauses *during* a speaker's conversational turn was predictive of positive social ratings, but prolonged silences following an interlocutor's turn (total length of no-responses and interspeaker pauses) were a negative predictor of social ratings. Similarly, the negative prediction power of the pause-to-speech ratio indicates that children who produced more speech were evaluated more positively than those who produced less speech.

Interestingly, autistic symptomatology as indicated by CARS-2 score was not a significant predictor of social ratings. This finding suggests that the types of behaviours that lead to higher CARS-2 scores may not be the same behaviours that listeners evaluate negatively in conversation. Some prior studies have found significant relationships between ASD severity and prosodic measures (Diehl et al., 2009; Paul et al., 2005), while others have found no relationship (Nadig & Shaw, 2012). Nadig and Shaw (2012) suggested that this failure to find a relationship between ASD symptoms and prosodic features could be due to a relatively small sample size (N=15). Although our sample is somewhat larger (N=21), the lack of significant relationship between ASD symptoms and social ratings could be a question of statistical power, a relative lack of variability in CARS-2 scores amongst the participants (16 of 21 participants had CARS-2 scores between 30 and 42), or a lack of sensitivity in the CARS-2 instrument in detecting atypicalities that are perceived more poorly by the raters of our samples.

Similarly, neither language nor nonverbal intelligence were predictors (either positive or negative) of ratings of perceived social skills. Of the demographic factors included in the model, only chronological age was a significant predictor of any perceived social skills: age negatively predicted likability, as younger children were evaluated more positively than older children. The lack of a statistical relationship between either language or intelligence and ratings of social skills is likely due to the fact that all of the children in our sample had language and intelligence in the normal range.

In line with our hypotheses, we find that raters are sensitive to prosodic aspects of conversation, especially rate of speech, speaker intonation range, quantity of speech produced, and the timing of pauses. These findings suggest possible targets for therapy and intervention. In particular, clinicians may want to encourage children with ASD to speak with a wide intonation range, not to speak too quickly, and to take contingent conversational turns without too long of a pause after their interlocutor finishes speaking.

We have presented an exploratory study examining the relationship between prosodic characteristics of the conversational patterns of fluent adolescents with ASD. While we have studied a number of linguistic variables in this study, we did not examine the possible relationship between the content of the conversations and social ratings. Qualitative analyses in the future could shed further light on the impact of linguistic content on social perceptions. Similarly, one limitation of the current study is that we did not compare speakers with ASD to NT speakers. We thus cannot know if the speakers with ASD would be judged more or less negatively than NT speakers on the five social dimensions, nor if the positive evaluations of the features described (such as wide robust range of f_0) would remain as positive predictors of social ratings when raters are evaluating both NT speakers and speakers with ASD. Future work should

continue exploring these questions with a control group of NT speakers for age, language, and intelligence.

Conclusion

Children with ASD who employed wide intonation ranges and paused during their own conversational turn are judged more positively on five social dimensions than children who employed narrower intonation ranges and paused less frequently. Conversely, children who failed to respond to their conversation partner, produced less speech, and talked more quickly were judged more negatively than children who responded to their conversation partner, produced more speech, and talked more slowly. These findings suggest that children with ASD vary in their conversational skills and that -- even when matched for language, age, and intelligence -- subtle prosodic differences in conversation can lead to different social judgments. It is important for researchers to acknowledge the wide variability in the social and linguistic skills of children with ASD, including the presence of sociable and talkative children with ASD. The results of this study thus challenge us to push beyond a stereotyped view of ASD and toward a more nuanced picture of the strengths and weaknesses of each child and understand the significant impact of prosodic factors on social perception.

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Table 1. Mean scores of the participants (SD in parentheses)

	Age	Nonverbal IQ	Vocabulary	CARS-2
ASD (N=21)	11.42 (2.27)	99.95 (17.57)	105.50 (18.93)	33.50 (6.28)

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Table 2. Significant predictors of likability ratings

	Estimate	Std. Error	t value	p-value
(Intercept)	86.961	7.297	11.917	0.000
Number of intraspeaker pauses	1.128	0.423	2.665	0.016
Total length of no-responses	-7.202	2.259	-3.189	0.005
Age	-0.162	0.055	-2.933	0.009

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Table 3. Significant predictors of outgoingness ratings

	Estimate	Std. Error	t value	p-value
(Intercept)	60.021	8.200	7.319	0.000
Robust range of f_0	46.437	9.936	4.674	0.000
Median syllable rate	-4.384	0.883	-4.966	0.000
Number of intraspeaker pauses	1.970	0.463	4.250	0.001
Pause-to-speech ratio	-22.796	2.912	-7.827	0.000

Table 4. Significant predictors of social skilfulness ratings

	Estimate	Std. Error	t value	p-value
(Intercept)	62.430	10.030	6.224	0.000
Robust range of f_0	24.146	9.927	2.432	0.028
Median syllable rate	-1.557	0.981	-1.588	0.133
Number of intraspeaker pauses	1.426	0.456	3.125	0.007
Total length of no-responses	-6.866	2.608	-2.633	0.019
Pause-to-speech ratio	-8.633	3.377	-2.557	0.022

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Table 5. Significant predictors of responsiveness ratings

	Estimate	Std. Error	t value	p-value
(Intercept)	113.040	7.423	15.229	0.000
Median syllable rate	-4.541	0.851	-5.334	0.000
Number of intraspeaker pauses	1.404	0.435	3.227	0.005
Pause-to-speech ratio	-19.453	2.788	-6.977	0.000

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Table 6. Significant predictors of fluency ratings

	Estimate	Std. Error	t value	*p*-value
(Intercept)	72.056	2.130	33.834	0.000
Total length of interspeaker pauses	-1.967	0.474	-4.146	0.001
Total length of no-responses	-5.181	1.587	-3.264	0.004

Table 7. Significant predictors of overall social skills ratings

	Estimate	Std. Error	t value	p-value
(Intercept)	379.141	40.690	9.318	0.000
Robust range of f_0	98.112	40.273	2.436	0.028
Median syllable rate	-10.145	3.978	-2.550	0.022
Number of intraspeaker pauses	5.863	1.851	3.167	0.006
Total length of no-responses	-26.631	10.581	-2.517	0.024
Pause-to-speech ratio	-49.903	13.699	-3.643	0.002