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Speech Rate Entrainment in Children and Adults with Autism Spectrum Disorder

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Master of Science in Speech-Language Pathology

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Abstract

Purpose: Conversational entrainment, the phenomenon whereby people modify their behaviors to match their communication partner, has been evidenced as critical to successful conversation. It is plausible that deficits in entrainment contribute to the conversational breakdowns and social difficulties exhibited by people with autism spectrum disorder (ASD). The present study examined speech rate entrainment in populations with and without ASD.

Method: Sixty participants including typically developing children, children with ASD, typically developed adults, and adults with ASD, participated in a quasi-conversational paradigm with a pseudo-confederate. The confederate’s speech rate was digitally manipulated to create slow and fast speech rate conditions.

Results: Typically developed adults entrained their speech rate to that of the pseudo-confederate, employing a faster rate in the fast speech rate conditions and a slower rate in the slow speech rate conditions. This entrainment pattern was not evident in adults with ASD, or the children populations.

Conclusion: Findings suggest that speech rate entrainment is a developmentally acquired skill and offers preliminary evidence of speech rate entrainment deficits in adults with ASD. Impairments in this area may contribute to the conversational breakdowns and social difficulties experienced by this population. Future work is needed to advance this area of enquiry.
Introduction

Conversation not only requires communication partners to produce and perceive speech, but to coordinate these behaviors to succeed. This coordination of behavior, termed herein as entrainment\(^1\), describes the tendency for people to modify their behaviors to more closely match those of their conversational partner. Considered a multi-level communication phenomenon, entrainment has been evidenced in many verbal aspects of communication including acoustic-prosodic speech properties (e.g., Lee et al., 2010), word choice (e.g., Brennan and Clark, 1996), linguistic style (e.g., Danescu-Niculescu-Mizil, Gamon, and Dumais, 2011), and syntactic structures (e.g., Branigan, Pickering, and Cleland, 2000; Reitter, Moore, and Keller, 2006). For example, using a quasi-conversational experimental turn-taking paradigm in which healthy participants read sentences aloud in response to hearing pre-recorded sentences produced by healthy and disordered speakers, Borrie and Liss (2014) observed that participants modified their speech rate and pitch variation to more closely match the properties of the proceeding audio sample. Entrainment has also been observed in nonverbal aspects of communication including facial expressions, gestures, and body posture (e.g., Furuyama, Hayashi, and Mishima, 2005; Louwerse, Dale, Bard, and Jeuniaux, 2012; Richardson, Marsh, and Schmit, 2005; Shockley, Santana, and Fowler, 2003), as well as patterns of laughter (e.g., Truong and Trouvain, 2012), eye gaze (e.g. Nakano, Kato, and Kitazawa, 2011), and yawning (e.g., Helt, Eigsti, Snyder, and Fein, 2010).

There is a well-established body of literature linking entrainment of verbal and nonverbal behavior to successful communicative interactions. From a cognitive perspective, there is

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\(^1\) Other terms that have been used to describe this communication coordination phenomenon include accommodation, alignment, convergence, and synchronization.
evidence that entrainment facilitates understanding of spoken language and successful exchange of information (Pickering and Garrod, 2004; Gill, 2012). Pickering and Garrod (2004) explain this in terms of shared situation models. That is, as communication partners modify their behaviors to more closely march one another, they find common representation on which they can ground their conversation, reducing ambiguities and misunderstandings. Entrainment has also been shown to support conversational fluidity, particularly by facilitating turn-taking decisions (Wilson and Wilson, 2005). Additionally, the degree of entrainment of speech features has been correlated with decreased inter-turn latencies and reduced conversational interruptions (e.g., Local, 2007). Entrainment is also important from a social and emotional perspective, helping to build and establish interpersonal relationships. For example, entrainment tracks with increased rapport, empathy, and intimacy between conversational partners (e.g., Bailenson and Yee, 2005; Chartrand and Bargh, 1999; Lee et al., 2010; Miles, Nind, and Macrae, 2009; Putman and Street, 1984; Smith, 2008; Street and Giles, 1982). As Borrie and Liss have previously summarized, entrainment “… serves as a powerful coordinating device, uniting individuals in time and space to optimize comprehension, establish social presence, and create positive and satisfying relationships” (Borrie and Liss, 2014, p 816). Accordingly, entrainment deficits or disruptions may result in decreased conversational success and reduced quality of life—specifically misunderstandings, poor interpersonal relationships, and frustrations for conversational interactants.

Entrainment is largely considered to be a developmental skill, emerging over the course of childhood (Jones, 2007). The evidence suggests that the development of entrainment begins as early as one-day old. For example, newborns have been observed to cry in the presence of other crying newborns, but not in the presence of computer-generated sounds with the same acoustic
properties (Simner, 1971). Jones (2007) demonstrated the gradual emergence of entrainment in infants for different behaviors. For example, infants produced the /a/ sound in response to parental production of the same sound at eight months, however, entrainment of paired /e/ sounds did not emerge until 14 months. As language skills increase and children begin using verbal output as a means of developing and maintaining social status (Chapman, 2000), entrainment begins to appear in a variety of acoustic-prosodic features of speech including rate, amplitude, utterance duration, and response latency (Welkowitz, Cariffe, and Feldstein, 1976; Oviatt, Darves, and Coulston, 2004). The gradual development of entrainment skills in spoken behavior is evidenced in a study by Welkowitz and colleagues (1976), where both younger (ages 5.4-6.1) and older (ages 6.4-7.2) children were able to synchronize pauses between vocalizations with one another, however, only the older group was able to successfully produce congruous pauses within vocalizations.

Given that entrainment is a developmentally acquired skill, it may be that populations with developmental delays exhibit impairments or delays in entrainment. One population that may be particularly vulnerable to co-existing entrainment deficits is people with autism spectrum disorder (ASD). From a clinical perspective, the term ASD is used to describe a developmental disorder characterized by social, communicative, and behavioral challenges (American Psychiatric Association, 2013). The overwhelming majority of people with ASD develop language at a slower rate than their typically developing (TD) peers (Le Couteur, Bailey, Rutter, and Gottesman, 1989), and most exhibit language deficits including limited vocabularies, impairments in syntactical skills, and limited comprehension abilities (Rapin and Dunn, 2003). Even when these language skills are intact, people with ASD have been shown to exhibit pragmatic deficits in social interaction—joint attention skills are often delayed, nonverbal
communicative behaviors are absent or unnatural, and social-emotional reciprocity is impaired (Carpenter, Pennington, and Rogers, 2002; Dawson et al., 2004; Mundy, Sigman, Ungerer, and Sherman, 1986). Paul and colleagues (2009) observed that people with ASD are more likely to provide inappropriate or irrelevant details and use overly formal language during conversation as compared with their TD peers. Deficits in topic management including perseveration, inappropriate topic shifts, and limited initiation may also be present (Klusek, Martin, and Losh, 2014). Furthermore, people with ASD commonly disregard their communication partner, exhibit poor reciprocal conversation skills, and struggle in cooperative activities (Klusek, Martin, and Losh, 2014; Liebal, Colombi, Rogers, Warneken, and Tomasello, 2008; Paul, Orlovski, Marcinko, and Volkmar, 2009).

Indeed the social, communicative, and behavioral challenges associated with ASD are far-reaching and such individuals often struggle with developing and maintaining interpersonal relationships (Taheri, Perry, and Minnes, 2016). Research has shown that children with ASD, relative to their typically developing peers, have fewer friends (Solish, Perry, and Minnes, 2010), less intimate relationships (Bossaert, Colpin, Pijl, and Petry, 2015), and higher rates of social exclusion (Dean et al., 2014). The developmental delays and characteristics of ASD, taken together, implicate potential entrainment deficits. While the issues of understanding and building interpersonal relations are likely multi-faceted and highly complex, we postulate that the presence of speech entrainment deficits may contribute to the disparities in conversational success between individuals with ASD and their TD peers.

The notion that people with ASD exhibit deficits in speech rate entrainment is largely unexplored. There is, however, a small but growing body of research demonstrating entrainment deficits in other elements of communicative behavior in people with ASD. Nakano and
colleagues (2011) have observed that the eyeblink entrainment found in typically developed (TD) adults engaged in face-to-face conversations is absent in adults with ASD. Studies looking at entrainment of facial expressions have observed that people with ASD entrain with less frequency and greater delays than their typically developing peers (Mathersul, McDonald, and Rushby, 2013; McIntosh, Reichmann-Decker, Winkielman, and Wilbarger, 2006; Oberman, Winkielman, and Ramachandran, 2009; Yoshimura, Sato, Uono, and Toichi, 2015). That entrainment deficits in non-verbal behaviors have been found in populations with ASD supports our hypothesis that entrainment deficits in speech behaviors may also exist.

Because speech characteristics “constitute one of the most significant obstacles to social integration” (Paul et al., 2005, p. 862) in populations with ASD, research regarding speech entrainment may be especially important. In the current study, we investigated speech entrainment in both children and adults, with and without ASD, to explore the hypothesis that people with ASD may present with speech entrainment deficits. Speech rate was selected as our speech feature of interest due to evidence that the speech rate of people with ASD generally falls within normal limits (e.g., Nadig and Shaw, 2012; Shriberg et al., 2001). Here, we addressed the following key research question: do children and adults, with and without ASD, modify their speech rate to more closely align with that of a pseudo-confederate? Based on evidence of nonverbal entrainment deficits in people with ASD, we hypothesized that children and adults with ASD would not modify their speech rate to the speech rate of a pseudo-confederate, thus implicating deficits in speech rate entrainment. Conversely, given the literature on speech rate entrainment in TD children and adults, we hypothesized that children and adults without ASD would modify their speech rate in response to the speech rate of a pseudo-confederate.
Method

Participants

Data were collected from 60 participants, compromising four experimental groups: (1) children with ASD (ASD-C; \( n = 15 \)), (2) gender-matched typically developing children (TD-C; \( n = 15 \)), (3) adults with ASD (ASD-A; \( n = 15 \)), and (4) gender-matched typically developed adults (TD-A; \( n = 15 \)). Descriptive age data for each group are summarized in Table 1. Each group included four females and 11 males. All participants were native speakers of American English with no self- or parent-reported hearing impairment. Language skills of the children participants in the TD-C group were confirmed within normal limits using two subtests (“Following Directions” and “Recalling Sentences”) of the *Clinical Evaluation of Language Fundamentals Fifth Edition* (CELF-5; Wiig, Semel, and Secord, 2013). Language skills of the adult participants in the TD-A group were confirmed within normal limits during an informal pre-experiment conversation with the experimenter.
Table 1. Age means, standard deviations, and ranges across experimental groups ($n=15$).

<table>
<thead>
<tr>
<th></th>
<th>ASD-C</th>
<th>TD-C</th>
<th>ASD-A</th>
<th>TD-A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Mean (SD)</td>
<td>10.07 (2.56)</td>
<td>9.92 (2.06)</td>
<td>28.66 (7.20)</td>
</tr>
<tr>
<td>Range</td>
<td>6-14</td>
<td>6-14</td>
<td>20-41</td>
<td>21-25</td>
</tr>
</tbody>
</table>

Note: “ASD-C”, “TD-C”, “ASD-A”, and “TD-A” refer to children with autism spectrum disorder, typically developing children, adults with autism spectrum disorder, and typically developed adults, respectively. SD refers to standard deviation.

Stimuli

Audiovisual stimuli for the present study featured one female native speaker (22 years old) of American English. Stimuli were created in a sound-attenuated booth with an industry standard microphone (Shure SM58, Niles, IL) and video camera (Canon EOS 70D, Tokyo, Japan), positioned to capture a view of the speaker’s head and shoulders, against a plain neutral backdrop. The speaker was encouraged to use her “normal speaking” voice while producing the stimuli for the study. Output elicited during the stimuli collection task was recorded digitally to a memory card at 48 kHz (16 bit sampling rate) and stored as individual recording files.

A total of 15 audiovisual recordings were made. In each recording, the speaker is shown holding a novel picture from a popular children’s book. The speaker introduces the picture, requests that participants describe what they see, and provides examples of what participants could talk about in each picture. Each recording was between 20-25 seconds in length. The original recordings were then digitally manipulated to create an additional two versions of each,
one with slower speech rate and one with a faster speech rate—80% and 120% of original speech rate, respectively. This resulted in two experimental speech rate conditions for each original recording—slow and fast.

**Procedure**

The experiment was conducted in a quiet room. Upon obtaining informed consent, participants were seated in front of a computer preloaded with the experimental procedure. Participants were informed that the experiment would require them to watch recordings of a person talking about a picture displayed on the computer monitor and subsequently describe the pictures themselves. They were informed that should continue talking until a visual timer (diminishing bar at the top of the screen) and auditory timer (sound of a beep) let them know that it was time to stop. Participants completed two practice trials with experimenter support to ensure complete understanding of the task.

Participants were then fitted with a wireless headset (Astro A50 Wireless System, San Francisco, CA) and told to begin the experiment. During the experiment, each participant was presented with 15 randomly selected recordings, which included five original recordings and five recording in each of the two speech rate conditions. No picture was seen twice. Verbal responses, termed response productions, from each participant were audio recorded via the headset microphone.

**Data Analysis**

The data set included the response productions for each participant in the slow and fast speech rate conditions. Thus, the total data set consisted of 600 response productions (10 per
participant). Each response production was analyzed for a measure of speech rate (syllables per second) using the acoustic analysis software Praat (Boersma and Weenink, 2015). Involuntary sounds (e.g., hiccups, coughing, sneezing) and periods of silence lasting over one second were not included in the calculation. However, because the overarching objective of this study was to examine rhythmic patterns of verbal output rather than communicative intent, all other vocalizations including part-word repetitions, whole-word repetitions, and filler words, were included in the calculation of speech rate.

Reliability Analysis

Ten percent of the total data set (60 response productions) were randomly selected according to a computer generated random number list and were reanalyzed by another judge to obtain interjudge reliability estimates for the dependent variable of speech rate. Reliability analysis confirmed that the agreement rate between the reanalyzed data and the original data was high ($r = .92$), with only minor absolute differences.

Results

Speech rate scores of the response productions in the slow and fast speech rate conditions were collected for each participant across the four experimental groups. To test the effect of condition (slow speech rate vs. fast speech rate) and group (ASD-C, TD-C, ASD-A, and TD-A) on speech rate, speech rate scores were analyzed using a two-factor mixed design analysis of variance. The within-participant factor was condition and the between-participant factor was group. Figure 1 provides a summary of these results.
The analysis of variance showed a statistically significant interaction between condition and group on speech rate scores, $F(3, 596) = 3.48$, $p = .016$, partial $\eta^2 = .03$. Therefore, simple main effects were conducted to examine differences in speech rate scores between the slow and fast conditions for each group. As there were four groups, four separate paired-samples $t$-tests with Bonferroni correction were carried out. Results revealed that speech rate scores for the TD-A group were significantly greater in the fast speech rate condition relative to the slow speech rate condition, $t(148) = 2.365$, $p < .021$, $d = 1.02$. There were, however, no significant differences in the speech rate scores between the fast and slow conditions for the other three groups. Thus, typically developed adults increased their speech rate when responding to recordings in the fast speech rate condition and decreased their speech rate when responding to
recordings in the slow speech rate condition. This speech rate modification was not evident in the typically developing children or the adults or children with ASD.

Simple main effects were also conducted to examine differences in speech rate scores between the four experimental groups for each condition. As there were two speech rate conditions, two separate tests were carried out. For the slow speech rate condition, there was a statistically significant difference in speech rate scores between experimental groups, \( F(3, 296) = 52.42, p < .001, \) partial \( \eta^2 = .35 \). Similarly, for the fast speech rate condition, there was a statistically significant difference in speech rate scores between experimental groups, \( F(3, 296) = 67.17, p < .001, \) partial \( \eta^2 = .41 \). Thus, participants performed differently in both the slow and fast speech rate conditions, with differences mediated by group.

Follow-up post hoc independent \( t \)-tests with Bonferroni correction demonstrated that during the slow condition, the speech rate scores of the TD-A group were significantly different than those of the ASD-A group, \( t(148) = 4.27, p < .001, d = .74 \), the TD-C group, \( t(148) = 10.45, p < .001, d = 1.77 \), and the ASD-C group, \( t(448) = 10.49, p < .001, d = 1.73 \). Speech rate scores of the ASD-A group were significantly different than those of the ASD-C group, \( t(148) = 6.22, p < .001, d = .98 \), and the TD-C group \( t(148) = 6.19, p < .001, d = 1.00 \). The difference between speech rate scores of the ASD-C and TD-C groups was not statistically significant. A similar pattern of results was observed during the fast condition. Again, the speech rate scores of the TD-A group were significantly different than those of the ASD-A group, \( t(148) = 6.77, p < .001, d = 1.11 \), the TD-C group, \( t(148) = 12.98, p < .001, d = 2.34 \), and the ASD-C group, \( t(148) = 11.27, p < .001, d = 1.83 \). Speech rate scores of the ASD-A group were significantly different that those of the ASD-C group, \( t(148) = 4.50, p < .001, d = .677 \) and the TD-C group \( t(148) = \)
6.20, \( p < .001, d = 1.02 \). The difference between the speech rate scores of the ASD-C and the TD-C group was not statistically significant.

**Discussion**

Typically developed adults, the TD-A group, modified their speech rate, depending on the speech rate of a pseudo-confederate. Adults with ASD, the ASD-A group did not make these speech rate modifications, nor did typically developing children or children with ASD, the TD-C and ASD-C groups, respectively. Taken together, these findings suggest that speech rate entrainment is a developmentally-acquired skill, which may be impaired, or essentially not acquired, in adults with ASD. We expand upon our findings and speculations below.

Here, we observed speech rate entrainment in typically developed adults. That is, the TD-A group employed a faster speech rate when responding to audiovisual recordings with a fast speech rate and a slower speech rate when responding to audiovisual recordings with a slow speech rate. This finding is supported by previous research showing speech rate entrainment with audio recording in healthy adults (Borrie & Liss, 2014). In contrast, however, speech rate entrainment was not evident in the adults with ASD. As seen in Figure 1, there is no significant difference in the speech rate of the ASD-A group in the slow or fast conditions. Indeed, entrainment impairments in people with ASD relative to TD peers have been previously reported with aspects of nonverbal entrainment, including eye-blinking (Nakano, Kato, & Kitazawa, 2011) and facial expressions (Yoshimura, Sato, Uono, and Toichi, 2015; Mathersul, McDonald, & Rushby, 2013). Authors of these studies speculate that the deficits in nonverbal entrainment in people with ASD may be linked to their deficits in social interaction and communication.
(Nakano et al, 2011; Mathersul et al, 2013). Recently, Yoshimura and colleagues (2015) provide some validation for these speculations, showing that reduced entrainment to facial expressions in adults with ASD was strongly correlated with increases in a measure of severity of social dysfunction.

Here, we postulate that impairments in speech rate entrainment in adults with ASD may also contribute to the pragmatic impairments observed in this populations. As mentioned previously, entrainment of speech features serves many important conversational functions related to developing interpersonal relations (Lee et al., 2010), establishing rapport (Putman and Street, 1984), and aiding turn-taking and interactional fluidity (Wilson & Wilson, 2005). Contrastingly, ASD is often characterized by difficulty developing and maintaining relationships (Taheri, Perry, & Minnes, 2016), less intimacy in friendships (Bossaert, Colpin, Pijl, & Perry, 2015), and poor reciprocal conversation skills (Kluseck, Martin, & Losh, 2014). While more research is needed, the present study reports speech rate entrainment impairments in ASD and implicates a possible link with the conversational deficits that characterize this population.

We did not observe evidence of speech rate entrainment in children between the ages of 6-14 years in the quasi-conversational, laboratory-based paradigm employed in the current study. Such a finding with typically developing children diverges from previous literature in which healthy children of a similar age have been observed to entrain to facial expressions (Oberman, Winkielman, & Ramachandran, 2009; Termine & Izard, 1988), lexical and syntactical speech features (Branigan, Tosi, & Gillespe-Smith, 2016; Hopkins, Yuill & Keller, 2016) and some acoustic-prosodic speech features, including that of speech rate (Welkowitz, Cariffe, & Feldstein, 1976; Oviatt, Darves, & Coulston, 2004). While differences in experimental paradigms may contribute to these discrepancies, particularly regarding speech rate entrainment
(see discussion below), inconsistencies may also indicate that different levels of entrainment are acquired at different stages of development. This idea is supported by previous studies that have reported on the gradual emergence of entrainment for different behaviors (Jones, 2007; Welkowitz, Cariffé, & Feldstein, 1976). For example, Welkowitz and colleagues (1976) found that the entrainment of interpersonal pauses (i.e. pauses between vocalizations of two speakers) occurs before the development of intrapersonal pauses (i.e. pauses within one speaker’s vocalization). Indeed, facial expressions are overt and afford easily accessible, visual information for the perceptual system. Linguistic elements of speech such as syntax and semantics afford auditory information but this information may also be readily detectable by 6-14 years of age. Speech rate, on the other hand, may require more complex detection mechanisms that require more time to be acquired. That is, the task of perceiving subtle changes in the speech rate of a pseudo-confederate and modifying one’s own speech rate accordingly, may demand more finely-tuned perceptual skills that emerge at later stages of development. Our data showing that typically developed adults did entrain to speech rate supports this speculation.

In an attempt to offer an explanation for the discrepancies in our data and that of previous research reporting speech rate entrainment in children between the ages of 7-10 (Oviatt et al., 2004), we turn to differences in the entrainment paradigms. In our study, participants on the whole engaged in a single conversational turn (35-45 seconds) before a different speech rate condition was introduced\(^2\). In contrast, the paradigm set forth by Oviatt and colleagues afforded participants multiple conversation turns lasting at least 20 consecutive minutes before moving on to a new speech rate condition. Accordingly, within the paradigm of Oviatt et al., participants had substantially more time to manipulate their speech rate to more closely align with that of the

\(^2\) Note, the stimuli were randomly presented so there is a chance that a participant could be sequentially presented two recording from the same speech rate condition.
pseudo-confederate. If we consider these two studies in tandem, the findings suggest that the ability to entrain to the speech rate of another may indeed begin developing within this age range, but that the skills required to rapidly perceive and modify speech rate within a single conversational turn may not yet be fully developed.

Given that typically developing children did not entrain their speech rate in the present study, it is of no surprise that children with ASD showed a similar result. Thus, it might be suggested that children with ASD do not have entrainment deficits, given that fully developed speech rate entrainment skills are not expected in their age and gender matched TD peers. However, such an absence of difference does not necessarily implicate an absence of deficits. Similar to our findings, previous studies have reported patterns whereby there is little or no difference between with TD and ASD populations on specific linguistic and working memory tasks in early childhood, however large discrepancies between groups become apparent in adolescence or adulthood (Luna, Doll, Hegedus, Minshew, and Sweeney, 2007; Annaz, 2006). Such patterns suggest that deficits may simply be masked in childhood, only becoming detectable when these skills emerge in TD populations at the appropriate developmental stage.

One other finding in our data is a significant difference between the speech rates of children and adults. Here, we see that both groups of children produced utterances that were significantly slower than the adult utterances, in both the slow and fast speech rate conditions. This finding is consistent with previous studies which indicate that speech rate increases with age (e.g. Nip and Green, 2007; Chermak, 1985). Additionally, we observed a significant difference between the speech rates of typically developed adults and adults with ASD—the ASD-A group produced utterances that were significantly slower than the utterances produced by the TD-A group. Research regarding speech rate in adults with ASD is sparse, however our finding is
supported more generally by work reporting that while adults with ASD may exhibit speech rates that are within typical limits, they are, on average, slightly slower than healthy adults (Shriberg et. al., 2005). No difference in speech rates were observed between typically developing children and children with ASD.

While largely theoretical at this stage, this preliminary study into speech rate entrainment in populations with ASD offers some important clinical considerations. It is well-known that diagnosing ASD in adulthood is a difficult and largely inaccurate process (e.g., Trammell, Wilczynski, Dale, & Mcintosh, 2013; Francis, 2012). Further research is certainly needed to flesh out a comprehensive understanding of speech entrainment in ASD populations, however should speech rate entrainment deficits be confirmed as a pervasive characteristic of this population, quantifying entrainment in the speech domain may offer an objective assessment to supplement existing tools and support a diagnosis. Further, where deficits exist, targeting skills that support entrainment may be efficacious.

However, before this, a number of important lines of investigation are needed. We summarize just a few here. First, the present study examined speech entrainment in a quasi-conversational paradigm with a pseudo-confederate in which the speech rate of the speaker was digitally manipulated. While this was specifically done for a high level of experimental control, future studies should target speech rate entrainment in embodied face-to-face conversations with naturally faster and slower speakers. Indeed, previous research has suggested that highly structured contexts (as in our study) may yield less obvious behavioral differences between children with and without ASD than more open-ended contexts (e.g., Landry & Loveland, 1989). Secondly, increased participant numbers and the inclusion of age groups not represented in this study would not only increase the power of the findings but allow us to identify exactly when
discrepancies between typically developing people and people with ASD emerge. Thirdly, but certainly not finally, research in this area should be linked with functional outcomes. That is, future studies in this area should examine the link between speech rate entrainment deficits and pragmatic functioning—in particular, the ability to converse with others and develop and maintain successful interpersonal relations.

**Conclusion**

In sum, we found that typically developed adults modified their speech rate in response to the speech rate of a pseudo-confederate, however this entrainment pattern was not evident in adults with ASD, or children populations. Thus, we provide preliminary evidence of speech rate entrainment deficits in adult populations with ASD and surmise that the absence of such entrainment may contribute to the conversational breakdowns experienced in this population. Future work is needed to advance this area of enquiry.
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