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Sensitivity to Orthographic Cues to Lexical Stress in Adolescent Speakers with ASD and Typical Peers

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Abstract

There are probabilistic cues to lexical stress present in English orthography. For example, approximately 70% of disyllabic English words ending with the letters ‘-ine’ have first syllable stress (e.g., ‘supine’ but note ‘decline’) whereas around 70% of words ending with ‘-ose’ have second syllable stress (e.g., ‘propose’ but note ‘glucose’). By the age of 12, native speakers of English are sensitive to these probabilities during silent reading and, when tested, tend to assign first syllable stress when reading a nonword such as ‘hatrine’ but second syllable stress when reading ‘dentose’ (see Arciuli & Cupples, 2006). The present study compared the ability of adolescents (13-17) with ASD to show this sensitivity to a group of typically developing peers matched for age and verbal IQ. Results suggest reduced sensitivity to these lexical stress probabilities in the group with ASD. The implications of these findings will be discussed.

Key Words: lexical stress, prosody, ASD, autism, probabilistic cues, reading, orthography
Introduction

Autism spectrum disorder (ASD) is a neuropsychological condition characterized by deficits in social-communication and the presence of restricted and repetitive behaviors (American Psychiatric Association, 1994) that affects approximately 1 in 110 children (Kogan et al., 2009). Since the first delineation of the autistic syndrome (Kanner, 1943), abnormal prosody has been frequently identified as a core feature of the syndrome for individuals with autism who speak (Baltaxe, 1984; Fay & Schuler, 1980; Ornitz & Ritvo, 1976; Paul, 1987; Pronovost, Wakstein, & Wakstein, 1966; Tager-Flusberg, 1981).

Prosody plays a pivotal role in human interaction. All of the world’s languages exhibit some characteristic pattern of prosodic rules, which provide suprasegmental cues to convey lexical, grammatical, pragmatic, and affective information. The term prosody refers to: 1) the assignment of relative prominence or stress to various units within the signal; 2) changes in pitch of the speech sound wave over time that make up its intonation contour; and 3) the rhythm and timing patterns that make up the phrasing of the utterance; expressed through fluency, rate, duration and pauses within speech events (Shriberg, Kwiatkowski, & Rasmussen, 1990). Acoustically, prosody is a composite of pitch (fundamental frequency), intensity (amplitude), and duration, as well as the co-variation of these variables (Stephens, Nickerson, & Rollins, 1983).

Atypicalities in prosody production are one of the most commonly-reported social-communicative features of autism spectrum disorders (ASD; McCann, 2003; Peppe, McCann, Gibbon, O’Hare, & Rutherford, 2007; Paul, Augustyn, Klin, & Volkmar, 2005; Shriberg et al., 2001) and also one of the earliest characteristics to appear.
(Schoen, Paul, & Chawarska, 2010; Werner, Dawson, Osterling, & Dinno, 2000; Wetherby et al., 2004). Prosodic atypicalities have been reported at all levels of ability in autism spectrum disorders (ASD), including high-functioning autism (Diehl, Watson, Bennetto, McDonough, & Gunlogson, 2009; Peppé, McCann, Gibbon, O'Hare, & Rutherford, 2007), although prosodic production deficits are not seen universally in this population. Simmons & Baltaxe (1975), for example, found that only four out of the seven adolescents with autism they studied had notable suprasegmental differences in their speech. Paul et al. (2005) reported abnormal prosody in 47% of the 30 speakers with ASD studied.

A range of prosodic production deficits have been reported in speakers with ASD, including problems with stress (Baltaxe, 1984; Baltaze & Guthrie, 1987; Baltaxe & Simmons, 1985; Fay, 1969; Fine Bartolucci, Ginsberg, & Szatmari, 1991: Fosnot & June, 1999; McCaleb & Prizant, 1985;), phrasing (Fine, et al., 1991; Thurber & Tager-Flusberg, 1993), and intonation (Baltaxe, Simmons, & Zee, 1984; Fay & Schuler, 1980; Fine et al., 1991; Paccia & Curcio, 1982). However, many of these early studies were plagued by methodological difficulties including small sample sizes, absence of normative data and contrast groups, poorly defined prosodic categories, and the use of subjective ratings, rather than objective measures.

Shriberg et al. (2001), in an attempt to address some of these problems, reported on a range of suprasegmental characteristics in continuous speech samples from adult speakers with HFA, using a standard assessment method, the Prosody-Voice Screening Profile (PVSP; Shriberg, Kwiatkowski, & Rasmussen, 1990). This study found significant differences from typical speakers, which were focused in a few areas,
most notably the use of stress and the presence of hypernasal voice quality. Paul and colleagues (Paul, Augustyn et al., 2005), in an experimental paradigm, also found that children with ASD showed deficits in stress production at both the lexical (e.g., RE-call versus re-CALL) and phrasal levels (e.g., CHOCOLATE ice cream versus chocolate ICE CREAM). Peppé et al. (2007) found that children with ASD had more difficulty using prosody for phrasal level stress when compared to typical comparisons matched on verbal mental age. Paul, Bianchi, Augustyn, Klin, and Volkmar (2008) reported differences at the acoustic level in the production of stressed vs. unstressed nonsense syllables in adolescents with ASD, when compared to typical peers. In addition, acoustic analyses of both spontaneous and imitative production of lexical stress for both real and nonsense words in speakers with ASD (Paul et al., 2008; Diehl & Paul, in press) reveal small but significant differences in both perceptual ratings of stress and acoustic measures of duration of syllables. Taken together, these findings suggest that producing appropriate stress patterns is one of the primary features of prosodic difficulty in speakers with ASD.

The term *lexical stress* refers to the contrast between strong and weak syllables within words. Syllable-timed languages exhibit predictable patterns of lexical stress. In contrast, stress-timed languages exhibit patterns of lexical stress that vary from word to word and are not predictable in a straightforward way. There is considerable debate regarding the classification of languages as stress- versus syllable-timed. Such differences may be more accurately viewed in terms of a continuum. Still, there are prototypical examples and English is often cited as an example of stress-timing. In English over 90% of words contain more than one syllable and, thus, exhibit lexical
stress. Lexical stress is critical for intelligibility (Klopfenstein, 2009; Slowiaczek, 1990) and perception of a speaker’s communicative competence (Paul et al., 2005)

**Stress assignment during reading**

There are probabilistic cues to lexical stress present in English orthography. For example, around 70% of disyllabic English words ending with the letters ‘-ine’ have first syllable stress (e.g., ‘supine’ but note ‘decline’) whereas around 70% of words ending with ‘-ose’ have second syllable stress (e.g., ‘propose’ but note ‘glucose’). Adults are sensitive to these probabilities during silent reading. Participants tend to assign first syllable stress when reading a nonword such as ‘hatrine’ but second syllable stress when reading ‘dentose’ (see Arciuli & Cupples, 2006). A triangulation of corpus analyses, behavioural testing and computational modelling demonstrated that sensitivity to these kinds of probabilistic cues to lexical stress during reading aloud follows a developmental trajectory in typically developing children aged 5-12 years (Arciuli, Monaghan & Seva, 2010). As children are exposed to an increasing volume and variety of written language in their reading materials, sensitivity to probabilistic cues increases. This appears to happen without having to draw children’s attention to these cues explicitly. See Seva, Monaghan and Arciuli (2009) for additional modeling work comparing probabilistic versus rule-based approaches to stress assignment during reading aloud.

**The current study**

The findings of a range of studies that suggest difficulties in production of stress in speakers with ASD, as well as the results reported by Paul et al. (2008) as well as Diehl and Paul (in press) showing that acoustic features, particularly duration, are
disturbed even in imitation and nonsense word production, have led to the speculation (Diehl & Paul, in press) that some part of the difficulty in producing stress in these speakers may stem from subtle motor impairments that impact their ability to precisely reproduce the prosodic patterns of other speakers in their environment. Shriberg et al. (2011) recently reported that both perceptual and acoustic measures of the speech and prosody of young children with ASD suggested these differences were more likely to stem from a failure to attune to the speech patterns in the environment, rather than from motor disorders. One way to test the hypothesis that it is attunement to ambient speech patterns rather than motor difficulties that lead to prosodic production differences is to use a task that does not require overt speech.

The current study investigates how adolescents with ASD respond to the lexical stress assignment task reported in Experiment 4 by Arciuli and Cupples (2006), in which participants are given a written list of disyllabic nonwords that contain probabilistic biases towards either first or second syllable stress and are asked underline the syllable they think should receive emphasis. This task has to potential to elucidate participants’ underlying knowledge about lexical stress patterns in English, without the requirement that they replicate these patterns in their own speech. To insure that adolescents would perform similarly to the adults in the Arciuli and Cupples (2006) study, a group of typically developing students was matched for age and verbal IQ to a group of adolescent speakers with ASD. The Arciuli and Cupples task was then replicated with these participants.

Method

Participants
Twenty-two typically developing (TD) adolescents, and twenty-three with high functioning autism spectrum disorder (ASD), all native monolingual speakers of English with normal or corrected-to-normal eyesight and normal hearing participated in the study. All participants had non-verbal IQ scores above 70 and spoke in full sentences. The ranged in age from 13-17. Descriptive information on the two participant groups appears in Table 1. There were no significant differences between the two groups in terms of age, verbal IQ, language scores on the CELF-IV (Wiig et al., 2004), or Gray Oral Reading Test (Gray, 1999). The group with TD contained more girls (8) than the group with ASD (3).

INSERT TABLE 1 ABOUT HERE

The group with typical development was screened for ASD using the Social Communication Questionnaire (Rutter, Bailey, & Lord, 2003). None of the TD participants met criteria on this screener. Family history questionnaire responses also confirmed that none had any history of autistic symptoms, or family members with ASD. The participants in the ASD group had all been diagnosed previously by medical professionals or multidisciplinary teams as showing this syndrome. The ADOS-G (Lord et al., 2000) and ADI-R (Lord, 1994) was used to confirm diagnoses. All participants in the ASD group met criteria for ASD on both the ADOS-G and ADI-R.

Procedure

This study employed the same task as that reported by Arciuli and Cupples (2006) with a reduced set of stimuli to avoid fatigue in these younger participants, who were also undergoing a larger battery of testing as part of their participation in an ongoing research project. The 48 stimuli from the Arciuli and Cupples report were
divided into 4 lists of 12 stimuli each. Each participant completed one of the four lists of 12 stimuli, and list presentation was rotated randomly among participants.

The written stimuli were presented on a sheet of paper. Written instructions were read to the participant by a trained research assistant, who also gave the practice stimuli and made sure participants understood the task. The research assistant was available throughout the task to answer any questions the participant had. Participants were instructed to underlined parts of the written words to indicate whether they thought emphasis should be placed closer to the beginning (first syllable) or to the end (second syllable) of each word on the list. Appendix 1 displays the task instructions and the four lists of stimuli.

**Results**

As expected, typically developing adolescents showed sensitivity to probabilistic orthographic cues to lexical stress. On average they assigned first syllable stress to disyllabic nonwords which contained cues to first syllable stress 68.2% of the time. In contrast, as a group, they assigned first syllable stress to disyllabic nonwords containing cues to second syllable stress only 41.82% of the time. A paired samples t-test revealed that his difference was significant ($t(21) = 3.15, p = .005$). This result indicates that typically developing adolescents show the same sensitivity to probabilistic orthographic cues to lexical stress as the adults reported in Arciuli and Cupples (2006).

On average, adolescents with ASD assigned first syllable stress to disyllabic nonwords which contained cues to first syllable stress 55% of the time. In contrast, they assigned first syllable stress to disyllabic nonwords containing cues to second syllable stress 46.02% of the time. A paired samples t-test showed this difference was not
significant ($t(25) = 1.58, p = 1.26$). Thus, adolescents with ASD did not appear to show the same sensitivity to probabilistic orthographic cues to lexical stress as the typically developing adolescents or the adults reported in Arciuli and Cupples (2006).

**Discussion**

Previous studies have found a rich source of probabilistic cues to lexical stress in English orthography and shown that adults, children and computational models are sensitive to these regularities (e.g., Arciuli & Cupples, 2006; Arciuli et al., 2010; Seva et al., 2009). In particular, Arciuli and Cupples (2006) showed that adults respond to probabilistic cues to lexical stress in disyllabic nonwords in predictable ways. A separate body of research indicates that many individuals with ASD exhibit difficulties with prosody, and with stress patterns in particular, although whether the source of these problems is attunement to ambient language or motor difficulties has not been clear.

The present study revealed that adolescents with ASD do not appear to show the same sensitivity to rules for lexical stress as do typically developing age mates. Since there was no requirement for participants to produce the words, motor explanations cannot account for this difficulty. The findings lend weight to the suggestion of Shriberg et al. (2011) that it is a lack of attunement to the fine details of ambient language conventions that underlie this deficit.

It seems likely that sensitivity to probabilistic cues in language (be it oral or written language) is underpinned by the capacity for implicitly detecting regularities – known as statistical learning (SL). See Arciuli and Simpson (in press a) for discussion. For example, recent research has shown that the capacity for SL is positively related to
reading ability (Arciuli & Simpson, in press b). One possibility is that impaired language function in ASD, including impaired prosodic processing, might be associated with deficits in SL…

If SL is shown to be unimpaired in ASD then alternative explanations for the results of the current study need to be explored. One possibility is that individuals with ASD are sensitive to probabilistic cues to lexical stress in English orthography but that this sensitivity is somehow overridden by faulty prosodic processes during the act of silent reading – perhaps via a faulty inner voice. Interestingly, there is an emerging of body of research on effects of lexical stress during silent reading that might be relevant to pursuing this possibility (e.g., Ashby & Clifton, 2005; Breen & Clifton, 2011).

References


Table 1. Mean (and standard deviation) for diagnostic groups

<table>
<thead>
<tr>
<th></th>
<th>TD (n=22)</th>
<th>ASD (n=26)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>15.0 (1.2)</td>
<td>15.0 (1.5)</td>
</tr>
<tr>
<td>Verbal IQ(^1)</td>
<td>105.0 (12.3)</td>
<td>109.1 (22.4)</td>
</tr>
<tr>
<td>CELF Total Score(^2)</td>
<td>107.1 (10.1)</td>
<td>99.5 (18.6)</td>
</tr>
<tr>
<td>GORT Score(^3)</td>
<td>107.3 (16.9)</td>
<td>98.9 (24.3)</td>
</tr>
<tr>
<td>% male</td>
<td>64</td>
<td>88</td>
</tr>
</tbody>
</table>

\(^1\) Verbal IQ score on *Differential Abilities Scale* (Elliott, 2007), 1990) for ASD group; on *Wechsler Abbreviated Scale of Intelligence* (Wechsler, 1999) for TD group.

\(^2\) Composite standard score on *Clinical Evaluation of Language Fundamentals-IV* (Wiig, Secord, & Semel, 2004)

\(^3\) *Gray Oral Reading Test* (Gray, 1996) Developmental Quotient
APPENDIX 1
Stress Assignment Task: Instructions

In this research, we are interested in examining the way in which people read words aloud.

We will give you a list of nonsense words to read. Although the words are not real English words, you could read each one aloud as though it were a real word. When we read words, we usually place more emphasis or stress on one part of the word relative to the other. For example, look at the following two lists of real English words. When people read aloud the words in List 1, they usually put more emphasis on the beginnings of the words, but when they read aloud the words in List 2, they usually put more emphasis on the word’s endings. Read the words to yourself and make sure that you can tell the difference. If you are in any doubt, please ask the experimenter to help you.

<table>
<thead>
<tr>
<th>List 1</th>
<th>List 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Beginning emphasis</strong></td>
<td><strong>Emphasis on the end</strong></td>
</tr>
<tr>
<td>SETtle</td>
<td>afFAIR</td>
</tr>
<tr>
<td>LISten</td>
<td>sucCESS</td>
</tr>
<tr>
<td>MARry</td>
<td>proVIDE</td>
</tr>
<tr>
<td>GAther</td>
<td>emERGE</td>
</tr>
<tr>
<td>SCANdal</td>
<td>adVICE</td>
</tr>
<tr>
<td>SHERiff</td>
<td>techNIQUE</td>
</tr>
<tr>
<td>HAVen</td>
<td>deNY</td>
</tr>
<tr>
<td>GARMent</td>
<td>agREE</td>
</tr>
</tbody>
</table>
In this part of the experiment, we want you to decide how you would say the nonsense words listed on the pages that follow. **Just work through the list of nonsense words in the order in which they appear, and underline either the beginning of the word or the end of the word, depending on where you think you would put more emphasis when you said the word.** For example, if the nonsense word were ‘permish,’ would you say it with more emphasis on the beginning (permish) or the end (permish)? (Once again, if you are having difficulty, please ask the examiner to assist you.)

Although you should not feel pressured to work quickly, remember that we are interested in your initial impressions of the nonsense words, so try not to spend too long thinking about each one. Just work at a pace that’s comfortable for you.

If you have any questions, please ask the experimenter before you begin. **Thank you. Please turn over and begin the task.**
Please think about how you would say each of the following made-up words aloud. If you think that you would say the nonsense word with more emphasis on its beginning, then indicate that fact by underlining the beginning segment of the nonword (e.g., permish). If, on the other hand, you think that you would place more emphasis on the end of the nonword, then underline that segment of the word (e.g., permish). Ask the experimenter before you begin if you are in any doubt.

1a. breckage
2a. curban
3a. hunstroke
4a. hatrine
5a. setect
6a. undure
7a. partel
8a. fantern
9a. malise
10a. antend
11a. givert
12a. fontage
Please think about how you would say each of the following made-up words aloud. If you think that you would say the nonsense word with more emphasis on its beginning, then indicate that fact by underlining the beginning segment of the nonword (e.g., permish). If, on the other hand, you think that you would place more emphasis on the end of the nonword, then underline that segment of the word (e.g., permish). Ask the experimenter before you begin if you are in any doubt.

1b. fostpose
2b. troduct
3b. secline
4b. onsect
5b. fractise
6b. ventose
7b. masern
8b. messert
9b. hatchel
10b. dummon
11b. rancel
12b. brefect
Please think about how you would say each of the following made-up words aloud. If you think that you would say the nonsense word with more emphasis on its beginning, then indicate that fact by underlining the beginning segment of the nonword (e.g., permish). If, on the other hand, you think that you would place more emphasis on the end of the nonword, then underline that segment of the word (e.g., permish). Ask the experimenter before you begin if you are in any doubt.

1c. baldron
2c. dunrise
3c. regan
4c. lenture
5c. refend
6c. savern
7c. themise
8c. ampose
9c. nevoke
10c. hispel
11c. vegend
12c. oxpert
Please think about how you would say each of the following made-up words aloud. If you think that you would say the nonsense word with more emphasis on its beginning, then indicate that fact by underlining the beginning segment of the nonword (e.g., permish). If, on the other hand, you think that you would place more emphasis on the end of the nonword, then underline that segment of the word (e.g., permish). Ask the experimenter before you begin if you are in any doubt.

1d. aject
2d. lanage
3d. mucrose
4d. feduct
5d. ongage
6d. dorphine
7d. tanure
8d. levies
9d. vorsage
10d. espect
11d. plosure
12d. viscern