The nature of speech perception in children with phonological deficits: Evidence from event-related potentials (ERP)

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INTRODUCTION
Deficits in phonology are associated with two clinical disorders, speech sound disorder (SSD) and dyslexia. SSD is an articulation deficit characterized by persistent errors in speech production as compared to same-aged peers (Shriberg et al., 1997). Dyslexia is a written-language disorder characterized by difficulty decoding printed symbols (Lyon et al., 2003). Although dyslexia and SSD commonly co-occur (Lewis et al., 2011), the relationship between these underlying phonological deficits is unclear. The purpose of the current investigation was to determine how behavioral and electrophysiological measures of speech perception in children with dyslexia and SSD contribute to our overall understanding of the phonological mechanisms underlying these distinct, yet related disorders.

Behavioral studies have found speech perception deficits in children with dyslexia and SSD, but considerably less is known about underlying neural processing of speech sounds in these children. Neuroimaging research shows that children with dyslexia exhibit different patterns of brain processing as compared to their TD-peers during speech perception (Lyttinen et al., 2005) including delayed processing and widespread neural activation, which may be indicative of increased processing efforts in these children as compared to their TD-peers (Molfese et al., 2008). Very few neuroimaging studies have investigated neural processes in children with SSD, but this research suggests that individuals with SSD exhibit differential patterns of neural activation when compared to their TD-peers (Preston et al., 2012; Tkach et al., 2011). To our knowledge, no neuroimaging studies have compared children with SSD and children with dyslexia. The current study investigated event-related potentials (ERPs), which are time-locked components of the ongoing electroencephalographic signal generated by the brain during neural processing. Thus, our aim was to determine whether children with dyslexia, SSD, or both exhibit similar patterns of delayed and widespread neural activation during speech perception tasks.

We hypothesized that as compared to TD-children, children with dyslexia would exhibit poorer behavioral discrimination for an acoustic-phonetic contrast of place-of-articulation (/da-ga/), children with SSD would exhibit poorer discrimination involving a phoneme produced in error (/ra-wa/), and children with dyslexia+SSD would exhibit the poorest discrimination for both /da-ga/ and /ra-wa/. For the ERP tasks, we hypothesized that all children would exhibit similar ERPs for the /ba-wa/ syllable contrast, children with phonological impairments would exhibit delayed processing across widely distributed scalp regions for /da-ga/, and children with SSD or dyslexia+SSD would exhibit delayed processing across widely distributed scalp regions for /ra-wa/.

METHODS
Forty children (aged 7;6-9;6) were classified into four groups (dyslexia, SSD, dyslexia+SSD, and TD) based on measures of speech and reading. All children with SSD and dyslexia+SSD exhibited difficulty producing /r/. Children completed perceptual discrimination tasks for three acoustic-phonetic syllable contrasts and, in a second research session, completed syllable identification tasks for each syllable pair while ERP data was collected using an
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Electrical Geodesics Incorporated high-density 128-channel EEG/ERP system. The stimuli included three pairs of synthetic consonant-vowel syllables, each of which varied by a single acoustic parameter: /ba-wa/ (acoustic parameter: F1/F2 rise time), /da-ga/ (F3 onset frequency), and /ra-wa/ (F3 onset frequency/slope).

RESULTS

Behavioral results revealed that, as expected, children in all groups did not differ in their discrimination of /ba-wa/ (p=.477). Although children with dyslexia discriminated /da-ga/ similarly to their TD-peers (p>.05), children with SSD (p=.027) and dyslexia+SSD (p=.012) discriminated /da-ga/ more poorly than their TD-peers. There were no significant differences between children with dyslexia, SSD or dyslexia+SSD (all ps>.05). Thus, on average, children with any phonological deficit exhibited poor discrimination for /da-ga/. For the /ra-wa/ syllable contrast, only the SSD and dyslexia+SSD groups differed in their discrimination of this syllable contrast (p=.034), such that children with dyslexia+SSD discriminated /ra-wa/ significantly better than their SSD peers. Notably, all children in these two groups had difficulty producing /r/. It is possible these children utilized different underlying mechanisms to discriminate these particular phonemes.

Preliminary ERP results show that as expected, all children exhibited similar ERP patterns for the /ba-wa/ identification task. For the /da-ga/ task, TD-children showed faster brain processing as compared to their dyslexic and SSD peers, who eventually reached similar levels of neural discrimination as the TD-children, albeit 150 ms after the TD-children. Notably, the dyslexia+SSD children exhibited continued changes in brain processing and failed to reach any discriminatory brain state, as compared to the other groups of children. For the /ra-wa/ identification task, group differences were found only in a late-occurring ERP component (408-808 ms), a time period typically associated with more cognitive processes such as syntactic/semantic processing. Neither dyslexic nor TD-children showed discriminatory patterns between /ra-wa/ during this temporal range. Both SSD groups, however, showed active patterns of discrimination for /ra-wa/, suggesting lingering active phonetic discrimination processes were engaged well beyond the time period expected in typical development. Finalized data will be presented at the meeting.

DISCUSSION/CONCLUSION

Together, these findings suggest that children with dyslexia and SSD, while sharing an underlying deficit in phonology, present with unique patterns of perceptual performance. Clinical implications of these findings, including the utility of speech perception methodologies for early identification of children with SSD at risk for dyslexia will be discussed.

SELECTED REFERENCES


