









Children with developmental dyslexia demonstrate atypical speech production for multisyllabic words and phrases

Mahmoud Keshavarzi¹, Giovanni M Di Liberto^{2,3}, Fiona Gabrielczyk¹, Angela Wilson¹, Annabel Macfarlane¹, Usha Goswami¹

1. Centre for Neuroscience in Education, Department of Psychology, University of Cambridge

2. School of Computer Science and Statistics, Trinity College Dublin, Dublin, Ireland

3. Trinity College Institute of Neuroscience, Trinity College Dublin, Dublin, Ireland

Abstract

Dyslexia is a developmental disorder which presents as difficulties in reading and spelling, and is related to difficulties with phonology measurable from infancy. These primary difficulties have been conceptualised as deficits in 'phonological awareness', which refers to the ability to recognize and manipulate the syllable stress patterns, syllables, and phonemes that comprise spoken words. Despite considerable evidence for this 'phonological deficit' in children with dyslexia, their spoken word production appears normal, suggesting a disconnect between speech input and output processes. Here, we investigated spoken word production in dyslexia by measuring the speech amplitude envelope AE and pitch contour of multisyllabic spoken phrases and words, using a novel computerised task based on copying adult-produced oral target stimuli. Seventy-five children with and without dyslexia participated in the study. Our analyses showed that children with dyslexia were significantly worse at producing the AE of multi-syllabic stimuli compared to both age-matched and reading-level-matched control children. However, no group differences were evident for pitch contour production between children with dyslexia and agematched control children.



Methods

Participants

- 19 chronological age-matched-control children (CA, average age: 11 years 0 months)
- 20 reading-level-matched control children (RL, average age: 9 years 4 months)
- 19 children with dyslexia who were receiving an oral rhythmic intervention (DY1, average age: 11 years 4 months)
- 17 children with dyslexia who were awaiting intervention (DY2, average age: 10 years 8 months)

Stimuli: The auditory stimuli were 20 multi-syllabic words or phrases.

Aladdin Bambi Bob The Builder Dr Who Flu	ushed Away
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Pitch Contour

Two repeated measures ANOVAs, with group and repetition as factors were conducted separately for pitch and pitch-MI:

- DY1 was significantly better than RL (p = 0.003) and DY2 (p = 0.044) for pitch contour-MI.
- DY1 was better than CA (p = 0.075) for **pitch contour-MI**.
- No strong evidence was found for a learning effect, neither for pitch contour-r nor for pitch contour-MI.



A

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Stimulus^{.....}..... Stimulus

-50

Harry Potter	Horrid Henry	Madagascar	Over The Hedge	Scooby Doo
Shaun The Sheep	The Cat In The Hat	The Gingerbread Man	The Jungle Book	The Lion King
The Muppets	The Simpsons	The Smurfs	Wallace And Gromit	Winnie The Pooh

Experimental set-up: Participants were presented with the 20 auditory stimuli. During presentation of each stimulus, a picture providing a memory prompt (Panel A) and the speech amplitude envelope (AE) of the stimulus (Panel B) were presented on the task layout. The children were instructed to listen to the stimulus and to repeat three times what they heard, and they were encouraged to try to match their response line to the visual amplitude envelope display on each occasion. Their responses were by a microphone, with recorded an expected 60 responses per child. Each response was recorded over a time interval of 3 s. As the child repeated the stimulus, the envelope of the target stimulus with the child's response envelope overlaying were shown on each occasion on the main layout (Panel c).



Figure 1. Schematic depiction of sequence of events during a single trial for the speech stimulus "Harry Potter."



Figure 4. Examples of the amplitude envelopes (left), pitch contours (middle) and spectrograms (right) produced by selected individual children in each group for the target stimulus "Aladdin."



Children with dyslexia are significantly worse at producing the amplitude envelope of multi-syllabic targets compared to both age-matched and reading-level-matched control children.
No group differences were found for pitch contour production between children with dyslexia and age-matched control children.
It may be difficult to detect speech output problems in dyslexia as pitch contours are relatively accurate.

Results

Pearson correlation (r) and mutual information (MI) were used to quantify the similarity between the child's response AE and the child's response pitch contour and the AE and pitch contour of the target stimuli.

Amplitude envelope (AE):

Two repeated measures ANOVAs, with group and repetition as factors were conducted separately for AE-r and AE-MI:

- CA was significantly better than DY1 (p = 0.038), DY2 (p = 0.001), and RL (p = 0.005) for AE-r.
- DY1 was significantly better than DY2 (p = 0.039) for **AE-r**.
- DY2 was significantly worse than CA (p = 0.002), RL (p = 0.013), and DY1 (p = 0.041) for AE-MI.
- No strong evidence was found for a learning effect, neither for AE-r nor for AE-MI.

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Email address: mk919@cam.ac.uk