Rhyme, Rhythm and Dyslexia

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Introduction

1) Children with developmental dyslexia have specific problems with reading and spelling that cannot be accounted for by hearing or visual impairments, low intelligence, neurological damage or poor educational opportunities.

2) Behavioural studies agree that a core feature of developmental dyslexia across languages is a phonological deficit. Children with developmental dyslexia have difficulties in tasks such as deciding whether two words rhyme, in phonological short term memory tasks, and in rapid automatised naming tasks. However, the cause of the phonological deficit remains controversial.

3) In our recent studies of children with developmental dyslexia, we have been exploring relations between the basic auditory processing of cues to rhythm and phonological processing and literacy. This approach assumes that the primary unit of speech is the syllable. For syllable processing, temporal segmentation of the continuous acoustic signal is facilitated by particular patterns of amplitude modulation. An important cue is the rate of change of the amplitude envelope onset, also called rise time. Rise time is particularly important for perceiving stressed syllables and speech rhythm.

4) Two of our rise time tasks are presented here. One task measures amplitude envelope onset detection (Richardson et al., 2004) in a 2IFC task. Two sounds are heard, and the child picks the one with the sharper beat. The second measures beat categorisation (Goswami et al., 2002). When rise time is rapid, a strong percept of a "beat" against a constant background sound is experienced. When rise time is more gradual, the sound is heard as a single sound waxing and waning in amplitude. One sound is presented, to be categorised by the children.

5) These different auditory processing tasks were administered to children with developmental dyslexia in 3 languages varying in rhythm class. The languages were respectively stress-timed (English) and syllable-timed (French, Hungarian). As rise time is a fundamental property of auditory signals, similar results were expected across languages.

Methods

Participants:

- The poster summarises data from 4 different studies, containing 72 English (Goswami et al., 2002), 65 English (Richardson et al., 2004), 44 Hungarian (Csepe et al., in preparation) and 56 French (Muneaux et al., 2004) dyslexic and control (chronological age, CA + reading level, RL) children respectively. Participants were aged 9 – 11 years. All had nonverbal IQ in the normal range and had normal hearing abilities (500Hz at 20dB). In each country, children were selected on the basis of a diagnosis of developmental dyslexia, which was independently corroborated by the research team using a mixture of IQ, reading and phonological measures.

Auditory Measures:

- The English (Richardson et al., 2004) and Hungarian (Csepe et al., in preparation) children received the 2IFC task depicted in Fig 1 using a psychoacoustic task based on cartoon dinosaurs that made sounds. The English (Goswami et al., 2002) and French (Muneaux et al., 2004) children received the Winnie-the-Pooh beat categorisation task (Fig 1).

Phonological, Literacy and Vocabulary Measures

- These comprised measures of single word reading, nonword reading, phonological awareness (rhyme), RAN and phonological short-term memory suitable for each language. Receptive vocabulary and verbal and nonverbal IQ were also assessed in the English and Hungarian participants.

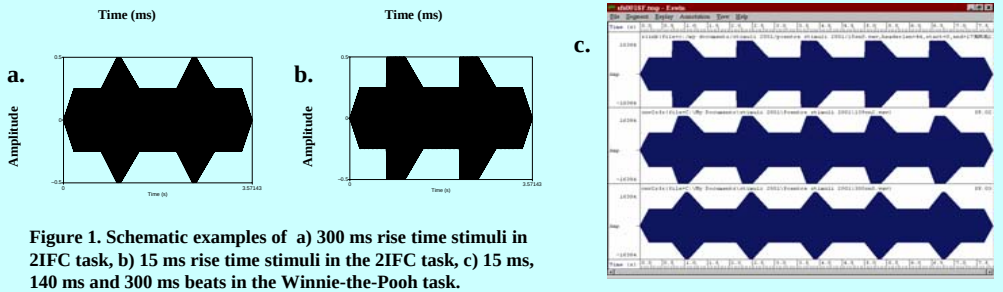
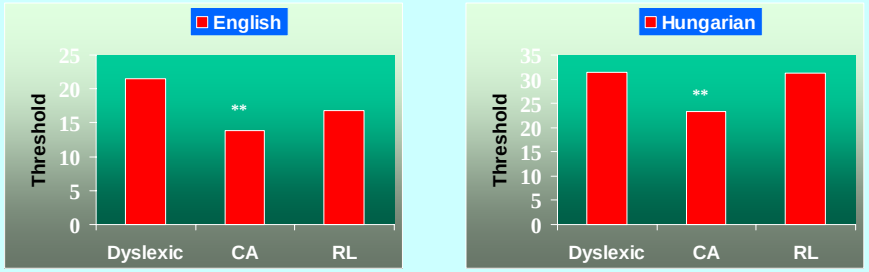


Figure 1. Schematic examples of a) 300 ms rise time stimuli in 2IFC task, b) 15 ms rise time stimuli in the 2IFC task, c) 15 ms, 140 ms and 300 ms beats in the Winnie-the-Pooh task.

Psychoacoustical Measures:

- **Amplitude Envelope Onset (2IFC) task:** 40 sine wave tones were presented with a frequency of 500 Hz and a linear rise time envelope that varied logarithmically from 15ms to 300ms (see Figure 1). The modulation was based on a square wave with a fall time of 350ms. Children heard the 300ms rise time as the standard and chose the dinosaur with the sharpest beat.
- **Winnie-the-Pooh categorisation task:** 40 stimuli identical to those used in the 2IFC task were used, except that they were comprised of 5 ramps. Children heard a single stimulus, and were asked to categorize it as either 2 sounds (sharp rise time) or 1 sound (extended rise time). During pre-training, the children learned that the sound with a sharp beat (2 sounds) was the sound made by Tigger and Eeyore swinging in turns on a toy swing with 2 seats. The single sound was the sound of Winnie-the-Pooh going down a helter-skelter slide by himself. The children could either categorise the test stimuli as 2 vs 1 sound, or as Tigger vs Winnie-the-Pooh.

A. Results in the Dinosaur 2IFC task by language



B. Results in the beat categorisation task by language

Categorisation Slopes in the Beat Detection Task

	Dyslexic	CA	RL
English	-0.03	-0.12**	-0.06
French	-0.06	-0.12**	-0.03

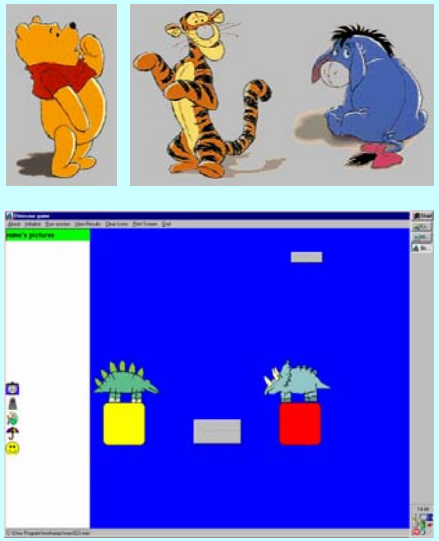


Figure 2: Schematics showing cartoon characters used in presentation of rise time stimuli in auditory tasks

Results

- Dyslexic children were significantly less sensitive than CA controls to rise time across tasks and languages.
- Performance in the phonological awareness tasks (rhyme, RAN, short term memory) was significantly related to rise time sensitivity across languages.
- Performance in the literacy tasks was also significantly related to rise time sensitivity across languages.
- These relations were maintained in stepwise regression analyses exploring the contributions made by the psychoacoustic measures after controlling for age and IQ.

Conclusion

Processing of rhythmic auditory cues is impaired in children with developmental dyslexia across languages. Degree of impairment is strongly related to the behavioural phonological and literacy deficits observed.

References

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