

## Little evidence for impaired event-structure coding in language-impaired children

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### Abstract

*Evidence from research suggests that language-impaired children, who present with reading difficulties, have problems processing a series of multiple events presented in close temporal proximity. This study measured the simultaneity thresholds of children with Specific Language Impairment (SLI), compared with a sample of children with Specific Reading Disability (SRD) and age-matched typically-developing children. In the individual experimental tasks, participants were asked to make judgments of simultaneity presented in both the visual and auditory modalities. Results suggest that children with SLI and SRD have higher visual but not auditory thresholds of simultaneity. These findings do not support the hypothesis of an auditory temporal processing deficit as a possible cause of SLI and SRD, nor do they provide evidence of a universal timing deficit.*

*However, impairments on the visual task have implications for the non-language specific nature of SLI and SRD and the role of visual processing in reading development.*

Around 10% of children struggle to learn to read (specific reading disability: SRD) or to speak their native language (specific language impairment: SLI) despite having average intelligence, no known physiological problems, and having grown up in a typical language learning environment (McArthur, Ellis, Atkinson, & Coltheart, 2008). The exact causes of SRD and SLI remain to this day relatively unknown and the fact that both represent heterogeneous groups; children who present with diverse language profiles and deficits, further complicates the matter. There is a great deal of overlap evident in both the spoken and reading abilities of children with SRD and SLI, which leads some researchers to question whether they represent the same or different conditions (Catts, Adlof, Hogan & Weismer, 2005; Bishop & Snowling, 2004; Goulandris, Snowling & Walker, 2000). Young children with a family history of dyslexia often experience delayed oral language development, and older children with dyslexia may demonstrate impairments on oral language tasks that do not involve reading or writing. Similarly, children with SLI usually have the same core phonological impairments as children with dyslexia (Bishop & Snowling, 2004). This suggests that SRD and SLI may have multiple causal factors that combine together in different ways to produce different patterns of reading and language impairment (Bishop, 2006).

One popular theory proposed by Paula Tallal (1980) suggests a disordered or delayed temporal processing system to be at the core of the difficulties language and reading-impaired children with have in discriminating and categorising the constituent sounds of a language. This theory of a temporal processing deficit proposes that these children are poor at discriminating and sequencing stimuli which are either brief in character or presented rapidly, within tens of milliseconds (ms) (Gibson, Hogben, & Fletcher, 2006; Benasich, Thomas, Choudhury & Lepp nen, 2001). However, the temporal processing deficit account of SLI and SRD has not been universally accepted. The heterogeneous nature of these disorders complicates research in this area. Some researchers would argue that only certain subgroups of language-impaired children present with such problems, while others argue for a more

speech-specific auditory processing deficit (Mody, Studdert-Kennedy & Brady, 1997). Not all children with dyslexia (approximately 45%) have impaired auditory processing skills (Rosen, 2003, Bailey & Snowling, 2002). Some children with dyslexia have problems processing simple speech sounds even though their ability to process analogous non-speech sounds is apparently intact. If this is indeed the case then it is necessary to establish whether such a deficit is specific to the auditory modality or whether a more general processing deficit prevails. Taking dyslexia as an example, it seems plausible that more subtle visual deficits might impact upon reading development but as of yet the magnocellular (Stein, 2003) and visual theories (Lovegrove et al., 1980) of dyslexia remain controversial.

### *Aim*

The principal aim of this present research investigate the nature of time perception deficits in children with SLI and SRD and to determine if such children display longer simultaneity thresholds on measures of temporal processing in the visual and auditory modalities, compared with typically-developing children.

## **Method**

### *Participants*

#### *Children with SLI*

Thirty-two children with a diagnosis of SLI, 21 males and 11 females, attending specific speech and language disorder (SSLD) classes, participated in this study. The children had a mean age of 8:8 (years; months) ( $SD = 1.63$  years), and ranged in age from six to 12 years.

The Clinical Evaluation of Language Fundamentals (CELF-IV; Semel, Wiig, & Secord, 2003) language test was administered by a Speech and Language Therapists (SLT) to obtain a measure of each child's receptive, expressive and core language skills. The CELF provided a total language score for each child ( $M = 71.94$ ;  $SD = 9.33$ ), as well as an expressive language score ( $M = 70.97$ ;  $SD = 10.37$ ) and a receptive language score ( $M = 83.78$ ;  $SD = 16.80$ ).

Non-verbal IQ was assessed using three perceptual reasoning (PRI) subtests: Block Design, Picture Concepts and Matrix Reasoning from the Wechsler Intelligence Scale for Children (WISC-IV; Wechsler, 2003). Processing speed (PSI) was assessed using the Coding and Symbol Search subtests from the WISC-IV (Wechsler, 2003). A mean PRI standard score of 97.32 ( $SD = 9.43$ ) and a mean PSI score of 91.23 ( $SD = 12.47$ ) was obtained.

#### *Children with SRD*

Twenty-five children with a diagnosis of SRD, 17 males and eight females, were identified through one reading class (attached to a mainstream primary school) and through a notice to parents explaining the purpose of this study placed on the Dyslexia Association of Ireland (DAI) website. The children recruited had a mean age range of 10.24 (years; months) ( $SD = 1.64$  years) and an age range of seven to 13 years. A standard mean PRI score of 101.68 ( $SD = 11.75$ ) and a standard mean PSI score of 93.38 ( $SD = 15.16$ ) on the WISC-IV (Wechsler, 2003) was obtained.

#### *Typically-developing children*

Twenty-two age-matched typically-developing children, 10 boys and 12 girls, were identified through local primary schools located in the same towns as the children attending the SSLD and reading classes. The children had a mean age range of 9.18 (years; months) ( $SD = 1.71$  years) and an age range of six to 12 years. Composite mean scores for the PRI subtests 108.33 ( $SD = 11.89$ ) and the PSI subtests 101.24 ( $SD = 13.27$ ) for each child were obtained using the WISC-IV (Wechsler, 2003).

### *Procedure – Auditory Task*

Employing an adaptive staircase measure, a Method of Limits, the auditory experiment was created in Matlab™ (version 7.0) and the stimuli were presented on a DELL laptop computer (Windows XP) using a set of Beyer Dynamic (DT 48) headphones. In each trial, the children's task was to determine whether they perceived the final tone of a group of six tones of 440 Hertz (Hz), of 0.1 seconds duration, presented to each ear, as a single tone, or as two tones; that is, whether they perceived the sixth tone as synchronous or asynchronous. There was a 50 millisecond pause between each tone, and there was a 2.5 second pause between each trial. A total of sixteen series of trials were presented.

In each series, the range of the asynchrony between each ear of the sixth tone varied between (0.1 seconds/Number of Offsets = 12) seconds to 0.1 seconds in steps of (0.1/12) seconds. 50% of the series were ascending - the tone asynchrony was initially (0.1/12) seconds, increasing in steps of (0.1/12) with each trial, to a maximum possible asynchrony of 0.1 seconds. The remaining 50% of the series were descending - the tone asynchrony was initially 0.1 seconds, decreasing in steps of (0.1/12) with each trial, to a minimum possible asynchrony of (0.1/12) seconds.

In 50% of the series (50% of the ascending and 50% of the descending series), the asynchrony of the sixth tone of the trial commenced in the left ear, and in the remaining 50% of the trials (50% of the ascending and 50% of the descending series) the asynchrony of the sixth tone commenced in the right ear. The four different series types (ascending/left, ascending/right, descending/left and descending/right) were presented in pseudo-random order. On the ascending series, the size of asynchrony on the trial where the participant first responded that they perceived the tone as asynchronous was recorded, the series was terminated, and the next series was presented. On the descending series, the size of asynchrony on the trial where the participant first responded that they perceived the tone as synchronous was recorded, the series was terminated, and the next series was presented. If the participant did not report asynchrony on an ascending series, or synchrony on a descending series, the next series was presented. Participants were asked to make their response using the keys 'P' (for synchronous) and 'Q' (for asynchronous) on a standard keyboard. Participants were administered the task on twice with a considerable break in between.

### *Procedure - Visual Task*

The aim of the visual experiment was to determine the thresholds for perceiving visual stimuli as simultaneous, using an adaptive staircase measure (a Method of Limits), which was run in Matlab™ (version 7.0). A DELL laptop computer (Windows XP), with a 15 inch monitor was used, with the refresh rate set to 60 Hz. The child's task was to determine whether they perceived the visual stimuli as 'simultaneous', that is presented together, or as 'asynchronous', i.e. presented in rapid succession. The stimuli consisted of two vertical grey bars separated by 13° of visual angle at which each bar subtended 3° x 10° of visual angle. The stimuli were displayed on a black background in an environment of low intensity ambient light. The bars flickered first on presentation before judgement of the simultaneity was made. The stimuli also increased and decreased in subthreshold luminance (peak luminance of 14.4 cd/m<sup>2</sup>) throughout the entire procedure. Participants made their response after each trial presentation by pressing the response keys 'Q' if the bars were perceived to be simultaneous and 'P' for asynchronous. This procedure was repeated until fifteen estimates of the threshold were obtained. Each trial was separated by a 2 second inter-trial interval. Participants were administered the task twice with a considerable break in between.

## Results

For the purpose of analysis the thresholds obtained from Time 1 and Time 2 were averaged to give an auditory and visual threshold for each participant.

### *Auditory Experiment*

Table 1. Mean and standard deviations for average auditory simultaneity thresholds for each of the three groups

Group	Average Auditory Threshold
SLI	49.45 (14.21)
SRD	56.26 (9.43)
Typically-Developing	56.45 (9.41)

A one-way ANOVA reported a significant difference across the three groups for the auditory simultaneity thresholds,  $F(2,75) = 3.32$ ,  $p = 0.042$ . Post-hoc analyses (Fisher LSD) reported significant differences between children with SLI and children with SRD ( $p = 0.034$ ) and children with SLI and typically-developing children ( $p = 0.035$ ).

### *Visual Experiment*

Table 2. Mean and standard deviations for the visual simultaneity thresholds (Time 1 and Time 2) for each of the three groups

Group	Average Visual Thresholds
SLI	100.77 (11.69)
SRD	96.40 (11.91)
Typically-Developing	94.13 (14.86)

There was no significant difference found across the three groups for the visual simultaneity thresholds.

### *Relationship of differences in auditory thresholds with language ability*

Further analysis using separate linear regression was conducted to assess the extent to which auditory and visual thresholds are a predictor of language impairment in SLI, as measured by PRI, PSI, CELF total language scores, receptive language scores and/or expressive language scores. Auditory thresholds were a predictor of total language scores ( $\beta = -.362$ ,  $t = -2.13$ ,  $p = 0.042$ ) which is likely due to the prediction of receptive language: the regression of receptive language scores over auditory thresholds revealed receptive language ability to be higher when thresholds were lower, consistent with the idea that higher thresholds indicate some abnormality in processing ( $\beta = -.52$ ,  $t = -3.36$ ,  $p = 0.002$ ). This compares with the regression of expressive language scores over auditory thresholds which proved non significant ( $\beta = -.113$ ,  $t = -.84$ , ns). Auditory thresholds also predicted performance on PSI scores ( $\beta = -.419$ ,  $t = -2.529$ ,  $p = 0.017$ ), indicating a generalized slowing in tasks involving language. Visual thresholds did not explain performance on language or IQ measures.

## Discussion

This study asked if the performance of language- and reading-impaired children would differ to the performance of typically-developing children on two tasks which determined thresholds for perceiving simultaneity in both the auditory and visual modalities. The adaptive staircase procedures employed revealed longer thresholds in the vision experiment than the thresholds obtained in the auditory experiment for the children with SLI and SRD.

Brecher (1932) originally reported thresholds of 55.3 ms in studies he conducted with a sample of healthy controls. The results from this auditory experiment were similar to Brecher's findings in that mean thresholds ranged from 49 to 57 ms. In line with Tallal's auditory temporal processing deficit it was anticipated that the children with SLI and SRD would take considerably longer to process the auditory stimuli. The sample used in this study did not reflect such a deficit and these findings concur with the opinion of Rosen (2003) that perhaps only sub-groups of reading-impaired children are affected. For children with SLI in this study, task performance was largely predicted by a child's language skills, in particular receptive language ability. Weak receptive language skills may hamper a child's ability to follow task instruction and to sequence auditory stimuli. Performance may reflect problems with sequencing, not inherent temporal processing deficits.

There was no significant difference reported between the groups for the visual thresholds. Considerably longer visual thresholds were found and the mean thresholds ranged from 93 ms for typically-developing children, 96 ms for children with SRD and 101 ms for children with SLI. These results may indicate that some children have problems choosing appropriate criteria for judging simultaneity in the visual modality. Given that the adult thresholds were within the expected range (60 ms), future research using this visual task should incorporate an adolescent sample to assess the development trajectory of temporal processing ability in the visual modality.

This study showed that not all language- and reading-impaired children have inherent problems with event-structure coding, but exhibit nonetheless, subtle impairments, which may influence a child's ability to sequence language in the correct and expected manner. The visual thresholds did not explain language impairment in SLI, whereas the auditory thresholds did, thus highlighting the modality-specific nature of language impairment. The results of this study do not support the notion of a universal temporal processing deficit in SLI and SRD. There was little support for there being a common temporal processing deficit, indexed by the low correlation between the auditory the visual thresholds, findings which are in line with those of Dawes & Bishop (2008).

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