



# AUDITORY AND VISUAL DYNAMIC PROCESSING: SEPARATE INFLUENCES IN READING?

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## INTRODUCTION

- Developmental dyslexia is often associated with deficits in detecting dynamic auditory and visual stimuli.
- In normal-reading children, auditory and visual dynamic sensitivity, respectively, might help constrain the phonological and orthographic skills, important for skilled reading<sup>1</sup>.
- It is not known how visual and auditory processing skills could combine to determine patterns of reading disability in dyslexics

## AIM

To determine how auditory and visual dynamic processing relate to component reading skills in developmental dyslexics and normal readers.

## METHODS

- Thirty nine adult subjects, 18 of whom had been diagnosed as dyslexic, participated in the experiment.
- All subjects completed a battery of psychometric tests of cognitive and literacy skills (see Table 1).
- The groups did not differ significantly on measures of non-verbal cognitive skills, but the dyslexics scored lower on measures of verbal cognitive and literacy skills.

## TABLE 1: PSYCHOMETRICS

Measure	Controls	Dyslexics	t-test Sig.
Similarities <sup>†</sup>	12.3 (2.1)	11.1 (2.1)	n.s.
Vocabulary <sup>†</sup>	13.5 (2.4)	11.0 (2.6)	p = 0.005
Picture Arr. <sup>†</sup>	12.3 (3.1)	11.3 (2.7)	n.s.
Block Des. <sup>†</sup>	14.0 (3.0)	13.6 (4.1)	n.s.
Digit Span <sup>†</sup>	12.9 (2.5)	9.0 (2.0)	p < 0.001
Reading <sup>‡</sup>	13.6 (1.2)	9.0 (3.2)	p < 0.001
Spelling <sup>‡</sup>	13.4 (1.5)	6.8 (2.8)	p < 0.001
Orth.	96.7 (0.03)	86.5 (0.2)	p < 0.001
Phon.	92.0 (0.04)	73.4 (0.1)	p < 0.001

Performance (mean and SD) of the dyslexic and control groups on psychometric measures. <sup>†</sup>Cognitive skills measures are sub-tests of the WAIS-R. <sup>‡</sup>Reading and spelling are from the WRAT-R. "Orth.", a measure of orthographic skills is % correct on a word-pseudohomophone discrimination task and "Phon.", a measure of phonological skills, is % correct on a pseudo-word reading measure.

## AUDITORY DYNAMIC PROCESSING

- Auditory sensitivity to four types of sinusoidal acoustic modulation was measured:
  - 2 Hz FM - previously shown to covary with phonological skills<sup>1,2</sup>
  - 2 Hz AM - reflects the syllabic rate of processing important in speech perception
  - 20 Hz AM - sensitivity previously shown to be reduced in dyslexia<sup>3</sup>
  - 240 Hz FM - a control task which is not processed dynamically

- Thresholds were measured using a standard 2 interval, 2 alternative forced-choice method, adjusting modulation depth by a weighted 1-up, 1-down staircase procedure<sup>4</sup>.
- All sounds were 1 second in duration, with an inter-stimulus interval of 500 ms. The carrier frequency was 1 kHz.

- Subjects reported which sound, first or second, was the modulated target tone.

## VISUAL DYNAMIC PROCESSING

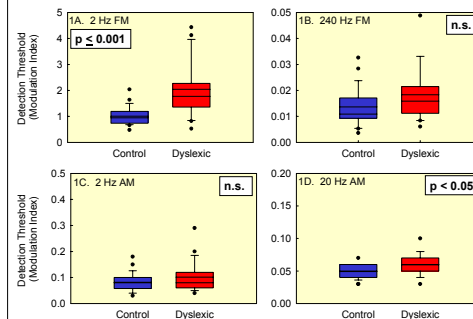
- Fifteen of the same dyslexics and 12 of the controls completed the measures of visual processing.
- Visual sensitivity to two types of stimulus was measured
  - Coherent motion - sensitivity previously shown to covary with orthographic skills<sup>1</sup>.
  - Coherent form - a control task which does not involve dynamic processing and does not correlate with motion thresholds<sup>5</sup>.
- Thresholds were measured using a standard 2 alternative forced choice method, adjusting motion or form coherence with a weighted 1-up, 1-down procedure<sup>4</sup>.
- Subjects indicated which of two patches, left or right, contained the coherent signal.

## RESULTS - PART 1 GROUP DIFFERENCES

### AUDITORY (See Figure 1, below)

- The dyslexics were significantly less sensitive than the controls to 2 Hz FM and 20 Hz AM.
- No group differences were found for 2 Hz AM or 240 Hz FM detection.

## FIGURE 1: AUDITORY THRESHOLDS

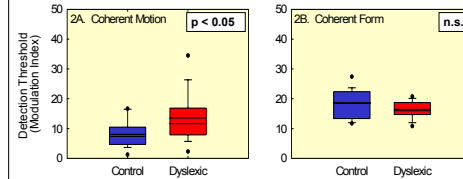


Performance of the dyslexic and control groups on the four measures of auditory processing skills.

### VISUAL (See Figure 2, above right)

- The dyslexics were significantly less sensitive than the controls to coherent motion.
- As found previously, there was no significant group difference for coherent form detection and thresholds on the two visual tasks did not correlate.

## FIGURE 2 - VISUAL THRESHOLDS



Performance of the dyslexic and control groups on two tasks of visual processing.

## RESULTS - PART 2 MULTIPLE REGRESSION ANALYSES

### RATIONALE

- Bivariate correlations indicated that variables such as general cognitive abilities modify interrelationships between sensory skills and reading sub-skills.

- Stepwise multiple regression analysis was used to delineate the contributions of sensory skills to variance in reading sub-skills, by controlling for variance in cognitive ability.

### FINDINGS

#### 1) Phonological Skills (Table 2)

## TABLE 2: MULTIPLE REGRESSION - AUDITORY

### DEPENDENT VARIABLE: PHONOLOGICAL SKILLS

Predictors	Multiple R <sup>2</sup>	R <sup>2</sup> Change
Cognitive Skills	0.210	
2 Hz FM	0.455	0.244
20 Hz AM	0.658	0.113

Non-contributing variables: 2 Hz AM, 240 Hz FM

- When entered first, cognitive skills (the sum of the sub-tests of the WAIS-R) accounted for 21% of the variance in pseudo-word reading.
- Sensitivity to 2 Hz FM accounted for a further 24.5% of the variance.
- Thresholds for 20 Hz AM explained a further, independent, 11.3% of the variance.
- Neither 2 Hz AM nor 240 Hz FM thresholds accounted for significant variance.
- No visual threshold accounted for significant variance in phonological skills.

### 2) Orthographic Skills

- The cognitive skills measure did not predict significant variance in performance on the word-pseudohomophone choice task.
- The only significant predictor of orthographic skills was performance on the visual coherent motion task, accounting for 20.7% of the variance.
- Coherent form thresholds did not account for significant variance, nor did any auditory thresholds.

## CONCLUSIONS

- Adult developmental dyslexics are less sensitive than controls to certain types of dynamic auditory and visual stimuli.
- Dyslexics and controls appear to perform equally well on psychophysical tasks which do not require dynamic processing.
- Auditory thresholds for detecting 2 Hz FM and 20 Hz AM predict significant, independent variance in phonological skills, after accounting for the effects of general cognitive ability.
- Visual coherent motion detection thresholds predict variance in orthographic skills.
- These predictive relationships might reflect causal relationships between sensory processing and the acquisition of reading subskills in dyslexic and normal readers.

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