Children with dyslexia classify pure tones slowly

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Developmental dyslexia is normally characterised by unexpected problems in learning to read for children of average or above average intelligence. Interestingly, however, slower speed of information processing appears to be a recurring symptom of dyslexia. There is a substantial literature on deficits in speed of access to the spoken word, initially discovered using the 'rapid automatised naming' test1. This test involves the rapid sequential naming of a series of 50 familiar stimuli presented simultaneously on a card. The authors showed that dyslexic children were slower to name colours, pictures, digits and letters than slow learners matched for reading age. Unfortunately, these and similar demonstrations of reduced speed of information processing have involved linguistic processing, and it is therefore not clear whether the deficit represents another correlate of the known linguistic abnormalities of dyslexic children or whether reduced speed of information processing reflects some deeper problem.

Five groups of children participated: 14 dyslexic children around 15 years old; 11 dyslexic children around 11 years old; 11 non-dyslexic children matched to the older dyslexic children for age and full IQ; 12 non-dyslexic children of similar IQ to the two dyslexic groups, matched for reading age with the older dyslexic children and for chronological age with the younger dyslexic children; and 9 non-dyslexic children matched for full IQ and reading age with the younger dyslexic children. All the dyslexic children had been diagnosed between the ages of 7 and 10, based on discrepancies of at least 18 months between actual and reading age. Their IQ levels fell in the normal to superior range on the Wechsler Intelligence Scale for Children and they had no known neurological deficit or primary emotional difficulty.

In pilot studies we established that dyslexic children showed the expected speed deficit in complex linguistically-based tasks. Consequently, in an attempt to find normal performance, we administered increasingly simple tasks — lexical decision, choice reaction, and finally simple reaction to a tone. In the lexical decision task, subjects were presented auditorily with a word (or, equally probably, a morphologically valid nonword) and had to say as quickly as possible Yes (if it was a word) or No (if it was a nonword). The dependent variable of interest was the response latency. In both reaction time experiments, subjects sat with a single button in their preferred hand, and their task was to press it as quickly as possible whenever they heard a low tone. In the simple reaction (SRT) task, no other tone was ever presented, but in the selective choice reaction (SCRT) task, there was an equal probability of a high tone being presented. If the high tone was presented the subject had to do nothing. The SRT and SCRT experiments were controlled by a BBC micro computer, using the sound generator to create the tones. The low tone used in both experiments was 350 Hz, and the high tone used in the SCRT experiment was 1400Hz, a two octave difference. In each task, subjects held a micro-switched button in their preferred hand, and 100 trials were administered. Results were recorded automatically, and mean and median latencies, latency variance and overall accuracy were calculated with a further program. For the lexical decision task, the stimuli used were 24 frequent single syllable words, (e.g. *shop*, *king*, *meat*), matched with morphologically correct non-words (e.g., *thop*, *hing*, *leat*), derived by altering the first consonant of each high frequency real word. Subjects were instructed to say 'yes' to a real word, or 'no' to a nonsense word, as quickly as possible. Voice onset latency was recorded automatically.

For each experiment the mean latencies were calculated, as were the standard deviations. Furthermore, since reaction time distributions are skewed, it is important also to derive the median reaction times to avoid the danger of outliers biasing the means. The median results for the three tasks are shown in figure 1, plotted on the same graph to facilitate comparison. To summarise the results: for the simple reaction task both groups of dyslexic children performed at the appropriate level for their age, and significantly faster than their reading age controls. However, for the SCRT and lexical decision conditions, the dyslexic children slipped back, to the extent that they were significantly slower than their chronological age controls and equivalent to their reading age controls. The same pattern of results applied for both mean and median latency. Furthermore, the dyslexic children were, if anything, less accurate than their age-matched controls, showing that the SCRT results cannot be attributed to some speed-accuracy trade-off effect. The 'by item' analyses of the lexical decision data suggested that the dyslexic children showed a qualitative deficit in lexical access speed, performing even more slowly than their RA controls for access to words. Full details of the results and procedure are presented in 2.

Our original research strategy was to administer a series of less and less complex information processing tasks, with the hope of finding some task for which the speed impairment disappeared. As expected, the lexical decision data indicated a speed impairment, with the dyslexic groups responding significantly slower than their CA controls (and even slower than their RA controls). Rather more surprisingly, however, the SCRT data led to a similar pattern of impairment, with the dyslexic groups having significantly slower performance than their CA controls, though in this case the performance was equivalent to their RA controls. These results suggest that at least two processes are impaired, with an initial quantitative impairment on SCRT speed together with a further impairment on lexical access speed which together result in an apparent qualitative deficit on the lexical decision task for words. Given the absence of phonological input or output in the SCRT task, these results suggest that, although differences in speed of lexical access may contribute to the overall problems in phonological processing, there is a further non-phonological deficit which is sufficient in itself to account for the quantitative impairment in SCRT.

In summary, the experiments reported here appear to be the first systematic, direct investigation of speed of information processing in dyslexic children. As the task complexity increased, the deficits shown by the dyslexic children became more marked. Both groups of dyslexic children performed normally on the simple reaction task. The two groups of dyslexic children showed an overall quantitative impairment on the selective choice reaction task. The two groups of dyslexic children showed an overall qualitative impairment on lexical decision time for words. It is likely that impairments of two processes combine to cause the lexical decision effect: namely a phonological deficit in lexical access speed together with a non-phonological deficit in stimulus classification speed. The non-phonological deficit is consistent with speed impairments in either perceptual classification or central decision processes.

References

1 DENKLA, M.B. & R.G. RUDEL. 1976. Rapid 'Automatized' naming (R.A.N.). Dyslexia differentiated from other learning disabilities. *Neuropsychologia*, **14**: 471-479.

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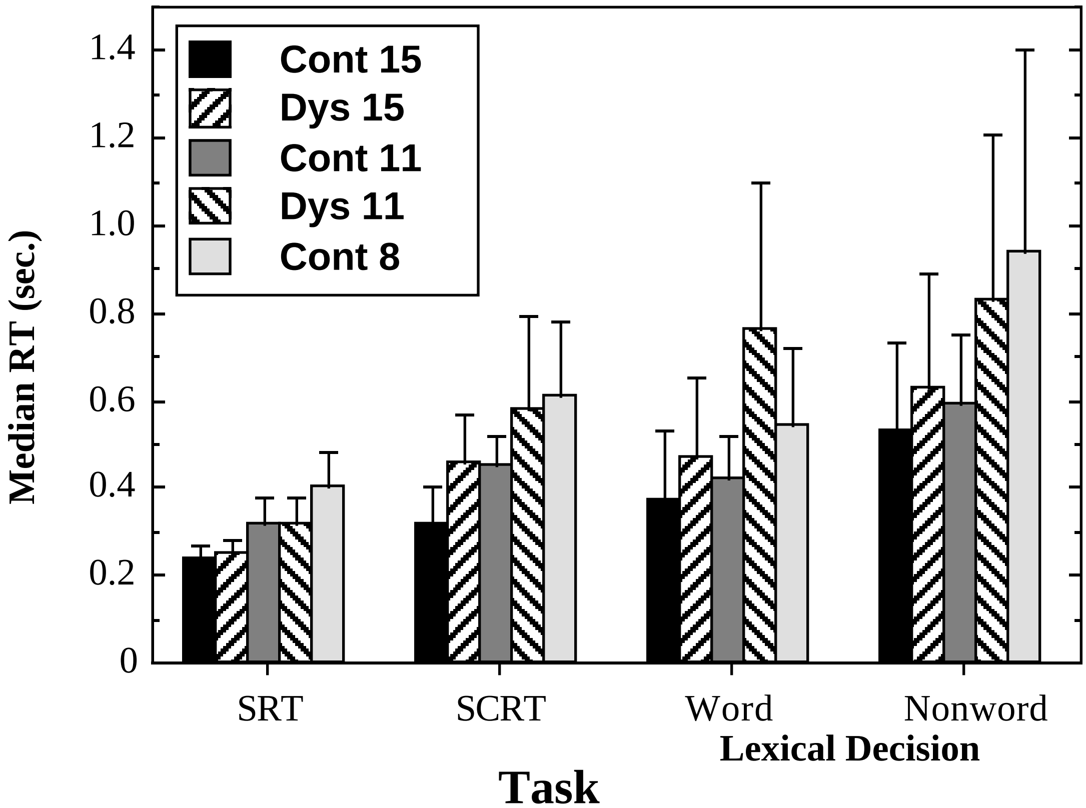
Figure 1. Median Latencies for the three experiments

The error bars represent the within-group standard deviation of the medians.
The group labels are as follows:
'Cont 15' — 15 year old controls
'Dys15' — 15 year old children with dyslexia
'Cont 11' — 11 year old controls
'Dys 11' — 11 year old children with dyslexia
'Cont 8' — 8 year old controls


Cont 15
Dys 15
Cont 11
Dys 11
Cont 8
Median RT (sec.)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
SRT
SCRT
Word
Nonword
Lexical Decision
Task