THE DISCRIMINATION OF CONSONANT CLUSTERS BY CHILDREN WITH SPECIFIC READING DIFFICULTIES (DYSLEXIA).

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ABSTRACT

Some children with specific reading difficulties (dyslexia) appear to show subtle speech-processing deficits, which may be linked to a general problem with auditory temporal processing [1]. Twenty-three reading delayed children were tested on their discrimination of natural minimal-pairs differing only in initial consonant-clusters. A strong effect of subject, and one of pairs was found. It is proposed that only some reading-delayed children have problems with processing complex speech events.

INTRODUCTION

One of the central issues in developmental language difficulty is that surrounding the range of possible limitations in perceptual and/or cognitive processing which could come to affect an individual's acquisition of reading and spelling skills. Empirical evidence seems to be accumulating that Specific Reading Difficulty (dyslexia) is, for many reading-disabled children, correlated with relative weakness in tests of phonological awareness [2], and of phoneme discrimination [3].

An early attempt at specification of a basic auditory-perceptual limitation in a language-disabled population came through the work of Tallal [4], who nominated a selective impairment of consonant perception in dysphasic children.

The proposal made by Tallal [1] was that formant transition duration is the limiting factor in difficulty with stop-consonant discrimination in language-impaired children. The question arises as to whether, even so, a deficit in the processing of one class of phoneme can be of such wide import in the general processing of fluent speech as to undermine the ability of some children toreadily process speech. Not all classes of speech contrast have been extensively tested in average and poor readers. Furthermore, results showing subtle but statistically-significant inferiority in stop-consonant labelling and discrimination ability for "language-disabled" children may be affected by the undifferentiated nature of the subject sample with respect to phonological difficulties.

Castles and Coltheart [5] examined the regular, irregular and nonword reading performance of 56 developmental dyslexics in comparison to that of 56 normally-developing readers, and looked at the possibility of dividing the reading-disabled sample into "phonological" and "morphemic" (surface) dyslexic groups based on patterns of reading errors. They concluded that developmental dyslexics form an amorphous population on these terms.

It has further been shown by Masterson et al. [6] that the errors made by two adult phonological dyslexics in phoneme discrimination tasks included evidence of problems with certain fricative contrasts, such as /f/ - /v/. Tests of consonant identification showed labelling errors, amongst others, of /p/ as /b/, using three vowel environments. This is of great interest for the issue of the importance of formant transitions, since only weak transitions exist between fricative consonants and adjacent vowel phonemes.

Pilot tests by Adlard (1993) had shown that some dyslexic children aged between 9 and 11 years did not discriminate reliably between minimal-pair monosyllabic words when the initial phonemes were fricatives ("fit" - "sit").

If a rapid sequence of complex acoustic changes is of itself sufficient to produce discrimination errors more frequently for dyslexic than for control children, it is possible that overall pattern complexity is an important variable. A contrast involving consonant phonemes articulated in rapid succession or one involving adjacent fricatives and stops would clearly provide acoustic complexity.

For this study, naturally-produced real-word tokens were employed, with clusters occurring only in word-initial position. Two conditions were tested: an OMISSION condition where a coarticulated second phoneme was either present or absent, and a SUBSTITUTION condition where only the identity of the second phoneme changed or not, the absolute initial consonant always being /s/. Tests of the reading of regular, irregular and nonword lists were also made.

METHODOLOGY

Subjects

Children were selected from within the mainstream school system in the NW London and S Hertfordshire areas, who had been recognised as having a persistent reading problem by their class teachers and who had received remedial teaching either from an in-school learning support base, or from a peripatetic SRD-trained specialist.

Each SRD child was considered by teaching staff to be probably of at least average intelligence. The mother-tongue of each child should be English, as factors surrounding the learning of another language in, say, a bilingual home, might complicate the mastery of written and spoken English. All children were between the ages of 7 and 13 years (inclusive).

A control group of six children was selected from the same school classes as the reading-impaired children, where possible. Work is continuing on the same measures for further CA matched children and for a group of reading-age matched controls.

Stimuli

Three word-lists were prepared. The first comprised 20 regular words, 14 mono- and 6 bi-syllabic. The second comprised 20 irregular words, 16 mono- and 4 bi-syllabic. They were derived from the Alpha list (7 yrs.) in "Words Your Children Use" by Edwards and Gibbon (London, 1964). All 30 nonwords employed were monosyllabic, and composed of either 3 or 4 letters.

Words containing clusters were chosen if they generated another word by either removing (OMISSION) or changing the identity (SUBSTITUTION) of the second consonant, and all words were within the likely vocabulary of the youngest subjects. Recorded utterances were used repeatedly in the generation of pairs, the catch trials being the presentation of exactly the same recorded utterance twice. A 1-second silent interval was used between words throughout, followed by a 5-second silent inter-pair interval to allow time for responding. The response was to be 2AFC "same" or "different", with trials randomised and the proportions of both equally likely overall (50%).

Eight pairs in each condition were produced, examples for OMISSION being "pay" - "play" and "fog" - "frog", and for SUBSTITUTION being "skip" - "slip" and "snow" - "slow".

All 23 experimental and 6 control children were asked to attempt the Neale Analysis - British edition (1989, revised). They were also given the Raven's Standard Progressive Matrices (1988) as an established measure of non-verbal intelligence.

For the reading-tests based on word-lists, voice recordings were made by use of an UHER M-646 microphone connected to an UHER 240 tape-recorder. The stimuli were acquired at a sampling rate of 48 kHz.onto a DAT recorder and then digitized onto a SUN computer at a sampling rate of 44.1 kHz. High-quality audio-tape was used, the signal being monaural throughout, to the right ear. The discrimination tests were run using a second UHER 240 tape-recorder and a pair of SENNHEISER 414 headphones.

Test procedure

A relatively quiet room was made available in schools. The three lists of words were presented first to each subject, typewritten in column form on a single sheet of paper, with the instruction that they should attempt in their own time to read each word orally. Self-correction was allowed and the last response noted. Subjects were told clearly that the non-words were simply "nonsense" and that they should merely read what they saw. Scoring of the non-word reading was based on whether or not the appropriate vowel sounds were made and whether all of the component phonemes were uttered. A pronunciation was counted as correct if it corresponded with a phonetically-regular interpretation.

Each block of 80 trials for speech discrimination was run continuously in either condition, taking approximately 12 minutes. The condition presented first was randomised. Subjects were told to listen to real-words given in pairs, one word at a time. In the silent period which followed each word-pair, they were to say whether these words were the same, or different. The number of errors made was expressed as a percentage, and a written list of them provided for pairwise analysis within and between subjects.

DATA ANALYSIS

The mean chronological age for the reading-delayed children was 10 yr. 9 mo., with a range of 5 yr. 10 mo. from 7 yr. 10 mo. to 13 yr. 8 mo. The mean delay was 2 yr. 9 mo., giving a mean reading age of 8 yr. 0 mo. For the six CA control children, the mean chronological age was 10 yr. 6 mo. with a range of 3yr. 3 mo. from 9 yr. 3 mo. to 12 yr. 6 mo.

A large range in error scores was obtained for the word-list reading tests. For regular words they varied from 0 to 55% with a mean of 20%; for the irregular words from 5 to 85% with a mean of 40%; and for the nonword list from 27 to 87% with a mean of 53%. There was also marked variability in performance on the speech discrimination tests: error rates for the "omission" condition varied from 0 to 37% with a mean of 3.9% whilst for the "substitution" condition they varied from 0 to 28% with a mean of 4.6%.

Table 1: Means and standard deviations consecutively for chronological age, Neale (accuracy) percentiles, Raven's percentiles, cluster substitution error rates, cluster omission error rates, and reading delay (months) for 23 children with specific reading difficulty.

Mn	129	13	76	4.6	3.9	34
SD	16	9	20	6.8	7.8	15

The equivalent control data is given below.

Table 2: Means and standard deviations consecutively for chronological age, Neale (accuracy) percentiles, Raven's percentiles, cluster substitution error rates, and cluster omission error rates for 6 age-matched normally-reading children.

Mn	126	74	88	1.1	0.5
SD	14	25	12	1.1	0.7

An ANOVA was obtained separately for the OMISSION and SUBSTITUTION data sets for the reading-disabled group. A significant main effect of subject was obtained for the consonant-cluster SUBSTITUTION condition ($F(7,22) = 15.30$, $p<0.0001$). Post-hoc analysis revealed that 5 of the 23 subjects made a mean number of discrimination errors which was significantly greater than for the remainder of the group. There was also an effect of stimulus pair ($F(7,22) = 2.50$, $p<0.0183$). The control-group data revealed no such effects.

An ANOVA for the consonant cluster OMISSION condition showed a significant effect of subject in the experimental group ($F(7,22) = 32.65$, $p< 0.0001$. A post-hoc analysis revealed that three of these children made a mean number of discrimination errors which was significantly greater than the remainder of the group. Here, again, there was an effect of stimulus-pair ($F(7,22) = 2.31$, $p< 0.0291$). The control-group data revealed no such effects.

DISCUSSION

It has been proposed that the durations of consonant-to-vowel transitions (F2 and F3), critical to the identification and discrimination accuracy of stop consonants, are perceived less reliably because of perceptual limitations of a temporal nature for certain language-impaired groups, such as reading-disabled children. Both stop-vowel and fricative-vowel syllables have a degree of pattern-complexity, but in order to estimate the potential of pattern-complexity itself to generate discrimination errors for specific test-materials, a series of naturally produced minimal-pairs was selected, to generate highly-complex speech pattern contrasts containing consonant-clusters.

An increase in acoustic pattern-difference might lead us to expect that the discrimination performance of each subject group for the OMISSION condition will be more reliable than their corresponding scores for the SUBSTITUTION condition.

Five children from within the reading-disabled group made significantly more errors in attempting to discriminate monosyllabic words bearing initial consonant clusters in the SUBSTITUTION condition, whilst only three of the children in this same group had particular difficulty with the discrimination of monosyllabic words bearing initial consonant clusters in the OMISSION condition. It would seem that the difference in complexity between these two types of word-pairing (generating reliably different levels of groupwise discrimination accuracy), consists of (1) specific changes in spectral information, and (2) the degree to which the portion of the speech signal relating to changes in phoneme-identity is composed of small differences in the duration of a series of brief component events.

The effect of pairs may be due, in whole or in part, to the discrimination performance in both cluster conditions of those subjects who performed less accurately throughout, to the extent that they appeared to constitute a sub-group within the reading-disabled sample.

The apparent strengths and weaknesses on word-list reading do not exclusively predict any given individual's pattern of accuracy on the speech-discrimination tasks used here. Relative weakness in morpho-phonemic skills might impact to some extent upon the decoding of regular and nonsense words alike, even though their decoding rules are taken to be simpler. Similarly, perhaps it is not improbable that specific weaknesses in phoneme discrimination can impair the consistent application of some morpho-phonemic rules, or interfere with their mastery. This may be particularly so where both the rules and the perceptual processing have to deal with acoustically-complex segments.

Generally, there appears to be no *necessary* link between the "phonological pattern" of reading errors and speech discrimination accuracy.

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