The phonological deficit in developmental dyslexia: is there a suprasegmental component?

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ABSTRACT

Adult dyslexics were tested on a range of tasks which were presented in two closely matched versions: a segmental version and a suprasegmental version. The tasks targeted phonological contrasts on one hand and the metalinguistic ability to manipulate phonological units on the other hand. The dyslexic group showed a deficit in suprasegmentals as well as segmentals but only when the tasks involved manipulation. We found no evidence that the representations of suprasegmental contrasts are impaired in the dyslexic participants.

Keywords: developmental dyslexia, adults, suprasegmentals, phonological contrasts

1. INTRODUCTION

Developmental dyslexia is widely believed to be caused either mainly [4, 5] or in part [7] by a deficit in phonological skills. Evidence in support of this position comes from the poorer performance of dyslexics relative to chronological age and/or reading age controls in phoneme deletion, segmenting, and blending tasks, as well as tasks such as nonword repetition which are also said to draw to some extent on phonological skills.

However, the nature of the phonological deficit itself is not yet fully specified, and one particular inadequacy in the current understanding of the phonological deficit is that it is restricted only to segmental aspects of phonology.

This is unsatisfactory for two reasons. On one hand, it does not escape the confound between the basic units of segmental phonology and the units of conventional orthography. In development, the construction of mental representations of spoken language is a reciprocal process between language acquisition and literacy acquisition [6], and it remains difficult to distinguish between knowledge of alphabetic units and knowledge of phonological segments in adulthood [1].

On the other hand, it is not possible to provide a comprehensive account of the putative phonological deficit without looking at phonology beyond the segment. It may be the case, for example, that dyslexia is a deficit in segmental phonology which leaves prosodic or suprasegmental phonology intact, but this possibility needs to be tested directly.

Addressing both these concerns requires identifying an area of phonology which is both independent of orthography and analogous to the phonological phenomena which have already been investigated in developmental dyslexia. One linguistic phenomenon which meets these criteria is the stress contrast in English, as seen for example in compound/phrase pairs such as *'toy factory* 'factory producing toys' (compound) versus *toy 'factory* 'model factory for playing with' (phrase). Since these forms are also entirely ambiguous in isolation in writing, they provide an ideal way to focus on phonological contrasts while sidestepping any possible confound with orthography.

Phonological contrasts are only one aspect of the phonological skills which have been investigated in individuals with dyslexia: metaphonological manipulation skills (i.e., the ability to isolate and manipulate phonological units) are also considered an important part of the evidence in favor of a core deficit in phonology [3, 4, 5]. Although many of the deficits which have been found to persist into adulthood in developmental dyslexia are metaphonological rather than affecting phonology in the narrow sense, again they only refer to segmental units rather than investigating suprasegmentals too.

The experiments presented here therefore address the skills related to phonological contrasts as well as metaphonological skills, while simultaneously taking account of both segmental and suprasegmental areas of phonology.

2. EXPERIMENT 1: MINIMAL PAIRS

The purpose of Experiment 1 was to explore the extent to which dyslexics might differ from non-dyslexics in their representation of phonological contrasts, as understood under the notion of minimal pairs.

2.1. Materials

Two types of minimal pair task were devised. One type aimed to test the participants' ability to assign the correct meaning to one or the other member of a minimal pair (the interpretation task). The other type aimed to test how well participants could identify a particular phonological contrast, excluding the meaning of the word and attending instead to its form (the recognition task). Both types included a segmental and a suprasegmental version of the same task.

Auditory stimuli for these tasks were read out from lists by two female native speakers of Scottish English. Acoustic analysis confirmed that the speakers produced reliable differences between the two types of stress pattern: duration was longer and pitch was higher for the first element of compounds (*toy*) and the second element of phrases (*factory*). Visual materials were also used in the interpretation tasks, one drawing for each member of each minimal pair.

2.1.1. Interpretation tasks

The **segmental** version consisted of 36 monosyllabic CVC words, such as *mat*, which forms a minimal pair with *bat*, and pictures to represent a mat and a bat. Items were based on the Minimal Pairs Discrimination with Pictures subtask of the PALPA [2] and contrasted in either place, manner, or voice; half the contrasts were word-initial and half were word-final. Only one member of each auditory minimal pair was used in the experiment.

The **suprasegmental** version was based on the stress contrast seen in pairs such as *'toy factory* and *toy 'factory*. There were 21 pairs, presented in the carrier sentence, 'This is what the _____ looks like.' Again, only one member of each pair was used in the experiment, and pictures were provided which represented the interpretation of both the item presented and its minimally different counterpart.

2.1.2. Recognition task

The **segmental** version consisted of 12 disyllabic minimal pairs based on /s/ and 12 pairs based on /t/ (e.g. *fussy*, *fuzzy*; *sonnet*, *sonic*). Both members of each pair were used.

The **suprasegmental** version consisted of minimal pairs based on the same contrast as before, but different items. Both members of each pair were used.

2.2. Participants

Participants were all university students whose native language was English. Twenty one students who had been given a formal diagnosis of dyslexia were matched with 21 students who had no history of speech or language difficulties. There were 7 males and 14 females in each group and the mean age of both groups was 24 years. Participants were matched for age and gender and also regional accent as far as possible.

2.3. Procedure

Participants were tested individually in a sound-deadened booth. Auditory stimuli were presented through headphones and controlled by E-Prime. Responses were made using specified keys on the keyboard. Accuracy (d-prime) and response time data were collected for each task.

In the interpretation task, sounds and pictures were presented simultaneously. Participants were instructed to select the picture which matched the word they heard. In the recognition task, participants were instructed to listen for a particular sound, and state whether it occurred in the first presented member of the pair or the second (e.g. whether /s/ occurred in *fussy* or *fuzzy*). The sound was a phoneme in the segmental version and a stress pattern in the suprasegmental version (either strong-weak or weak-strong).

2.4. Results of Experiment 1

2.4.1. Interpretation task

Both groups found the suprasegmental version harder than the segmental version (2x2 repeated ANOVA showed lower accuracy, $F(1, 15) = 187.728$, $p = .000$, and longer RT, $F(1, 17) = 80.093$, $p = .000$). Accuracy in the segmental version was at ceiling levels for both groups. There was also an interaction between the groups and the version of the task, with the dyslexic group

responding an average of 490msec faster than the control group in the suprasegmental version ($F(1, 17) = 5.208$, $p = .036$). There were no other interactions.

2.4.2. Recognition task

Again, both groups found the suprasegmental version harder than the segmental version (lower accuracy, $F(1, 18) = 128.782$, $p = .000$, and longer RT, $F(1, 17) = 32.589$, $p = .000$). There was no difference between the groups and no interaction.

3. EXPERIMENT 2: MANIPULATIONS

The purpose of Experiment 2 was to explore participants' ability to isolate phonological units and move them around within words. This demanded a higher level of metalinguistic awareness than in the previous experiment.

Two types of manipulation task were devised, pig Latin and spoonerisms, both with segmental and suprasegmental versions. In the pig Latin type, the task was to identify a phonological unit within a word, and then extract it from its original environment and move it to the end of the word (the segmental version followed Pennington et al [3]). In the spoonerism task, the units had to be extracted from two words presented together and had to be exchanged.

3.1. Materials

3.1.1. Pig Latin task

The **segmental** version consisted of 35 disyllabic words with either a word-initial singleton consonant or consonant cluster. Only the first consonant was involved in the manipulation: it had to be removed from the onset, placed at the end of the word, and made the onset of an extra syllable whose nucleus was always arbitrarily /e/ (e.g. *blanket* becomes *lanket-bey*).

The **suprasegmental** version consisted of 34 trisyllabic words with either a SWW or a WSW stress pattern. Only the main stress was relevant to the manipulation: it had to be moved onto the following syllable and the extra arbitrary unstressed syllable /ta/ was added at the end of the word (e.g. *'ca.len.dar* becomes *ca.'len.dar-ta*).

3.1.2. Spoonerism task

The **segmental** version consisted of 22 pairs of disyllabic words which both began with either a singleton consonant or a consonant cluster. Only the first consonant from both words was involved in the manipulation: they had to be exchanged, leaving the rest of the words intact (e.g. *plastic*, *craggy* becomes *clastic*, *praggy*).

The **suprasegmental** version consisted of 23 pairs of trisyllabic words, each pair consisting of a SWW pattern and a WSW pattern. The main stress had to be exchanged, leaving the rest of the words intact (e.g. *ca.'the.dral*, *'bad.min.ton* becomes *'ca.the.dral*, *bad.'min.ton*).

3.2. Participants

Participants were the same as in Experiment 1.

3.3. Procedure

Instructions as to the nature of the manipulation and practice examples were provided by the experimenter verbally to each participant. These were always provided in terms of 'sounds' ('the very first sound in the word') – no written examples were provided. Participants were required to state whether the manipulation they heard was correct or not, in terms of the instructions they had practiced.

3.4. Results of Experiment 2

3.4.1. Pig Latin task

The dyslexic group found these tasks harder than the control group (lower accuracy, $F(1,19) = 4.541$, $p = .046$, and longer response times, $F(1, 13) = 6.196$, $p = .027$). The suprasegmental version was again harder than the segmental version for both groups (lower accuracy, $F(1, 19) = 62.922$, $p = .000$, and longer response times, $F(1, 13) = 14.365$, $p = .002$). There was no interaction.

3.4.2. Spoonerism task

The dyslexic group was less accurate than the control group ($F(1, 19) = 12.076$, $p = .003$), but there was no difference in accuracy between the versions and no response time differences between groups or versions. There were no interactions.

4. DISCUSSION

Due to ceiling effects in the segmental tasks, it would be inappropriate to take the results of Experiment 1 to suggest that dyslexics are not impaired in the interpretation or recognition of segmental contrasts. However, since the results of

the suprasegmental tasks were not at ceiling for either group, they can be more readily taken at face value. What they suggest is that when the contrasts are suprasegmental, the dyslexic group is not impaired relative to the control group, either in recognizing the contrast (where they performed equally well with the controls) or in interpreting it (where they were faster to respond equally accurately with the controls).

If the performance of the dyslexic group is genuinely better than that of the controls, as evidenced by their shorter response times in the suprasegmental Interpretation task, this would suggest that dyslexics are at an advantage relative to controls when the meaningful information in speech is not associated with an orthographic representation. Non-dyslexics confronted with speech material will expect to be able to associate it with an orthographic template as well as listening to the speech sounds, but dyslexics might prefer to use other strategies as they construct the meaning of what they hear, including relying less on the orthographic route, which would stand them in good stead when an orthographic representation does not exist at all for the speech materials they encounter, as was the case in this experiment.

It was only in Experiment 2 that differences between the groups were found, with both a group effect and a version effect in the pig Latin task and a group effect in the spoonerism task (it appears that the lack of a version effect in the spoonerism task was due to a combination of a relatively easy suprasegmental version and a relatively difficult segmental version).

The finding that group differences appeared only in Experiment 2 tends to suggest that it was the requirement for the participants to isolate and manipulate particular phonological units (whether segments or a word's main stress) which differentiated between the dyslexics and the controls. In other words, the representation of phonologically contrastive units is not likely to be the source of the difference, but rather the ability to isolate these units from their location in a lexical item, treating them as objects which can be maneuvered and repositioned on demand. This draws on a wide range of metaphonological abilities – the ability to focus on the form of auditory words, segment them into relevant phonological units, move the target units to new positions, and recombine them with the sounds in their new location – and it is in the combination of these, it seems, that the dyslexics diverge from the controls.

5. CONCLUSION

The dyslexics do not seem to be impaired in suprasegmental areas of phonology, except when the tasks involve the manipulation of phonological units, with the heavier metalinguistic and working memory demands which this makes.

The finding that the representation of suprasegmental contrasts is not impaired could be argued to indicate that the phonological deficit in dyslexia is restricted to segmentals, leaving prosody intact. However, the segmental deficit itself remains open to question, considering the distance between the metalinguistic tasks generally used to diagnose it and underlying phonological representations in the narrow sense (as well as the closeness of the links between segments and alphabetic letters).

Escaping from the language-literacy overlap requires a move away from phonological investigations grounded in segments, and this study has shown that doing so is not only necessary but feasible.

6. REFERENCES

[1] Derwing, B.L. 1992. Orthographic aspects of linguistic competence. In: Downing, P., Lima, S.D., Noonan, M. (eds), *The Linguistics of Literacy*. Amsterdam: John Benjamins

[2] Kay, J., Lesser, R., Coltheart, M. 1992. *PALPA: Psycholinguistic Assessments of Language Processing in Aphasia*. Hove: Lawrence Erlbaum Associates

[3] Pennington, B.F., van Orden, G.C., Smith, S.D., Green, P.A., Haith, M.M. 1990. Phonological processing skills and deficits in adult dyslexics. *Child Development* 61, 1753-1778

[4] Ramus, F. 2003. Developmental dyslexia: a specific phonological deficit or general sensorimotor dysfunction? *Current Opinion in Neurobiology* 13, 212-218

[5] Snowling, M.J. 2000. *Dyslexia*. Oxford: Blackwell

[6] Treiman, R. 1997. Spelling in normal children and dyslexics. In: Blachman, B.A. (ed), *Foundations of Reading Acquisition and Dyslexia*. London: Lawrence Erlbaum Associates

[7] Wolf, M., O'Rourke, A.G., Gidney, C., Lovett, M., Cirino, P., Morris, R. 2002. The second deficit: An investigation of the independence of phonological and naming-speed deficits in developmental dyslexia. *Reading and Writing* 15, 43-72