Evidence for an Articulatory Awareness Deficit in Adult Dyslexics

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Dyslexia is widely considered to be associated with impaired performance on phonological awareness tasks. However, it is likely that orthographic knowledge also influences performance on these tasks. In this study, adult dyslexics, for whom reading is no longer a major problem, were compared to a control group on a measure of articulatory awareness, a task which is not confounded with orthography. The dyslexic group showed deficits on the task in comparison to the control group. We hypothesize that information about articulatory movements for specific phonemes is less accessible to dyslexics because of a deficient phonological processing system. Copyright © 2002 John Wiley & Sons, Ltd.

Keywords: phonological awareness; articulatory awareness; illiteracy; adult dyslexics; phonological processing

INTRODUCTION

Because of the strong association between phonology and learning to read (see Snowling, 2000 for a recent review of the field), tests of phonological awareness (e.g. spoonerisms; phoneme deletion) are widely used as screening devices for dyslexia. However, one difficulty has been that of establishing the causal relationship between phonology and literacy. Morais et al. (1979) were the first to show that illiterate adults also exhibit impairments on tests of phonological awareness, which indicates that these tasks are dependent on knowledge of the alphabet. Literate individuals suffering from a phonological processing deficit may be able to solve these tasks by using orthographic knowledge to by-pass their deficit. However, a phonological processing deficit should be readily detectable in tasks which cannot be solved with the use of orthography, such as articulatory awareness tasks.

There is some evidence to support the hypothesis that dyslexic individuals have difficulty accessing articulatory information. Montgomery (1981)

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compared eight and ten year old dyslexic children with reading age control children on an articulatory awareness task and a phoneme deletion task. In the articulatory awareness task, subjects are asked to repeat an orally presented phoneme and then match it with schematic drawings of the face, each with a characteristic constellation of articulators. The phoneme deletion task was based on the paradigm used by Bruce (1964), in which deleting a phoneme still results in a real word (e.g. “can you say ‘late’ without the ‘l’?”). Dyslexic children were impaired compared to the control group on the articulatory awareness task, even though they were equal to controls on the phoneme segmentation task.

Further evidence indicates that an articulatory awareness deficit may also be associated with acquired phonological dyslexia. Adair et al. (1999) report a patient with phonologic alexia resulting from ischemic injury to the anterior perisylvian region of the left hemisphere. The patient had a relatively selective impairment in grapheme to phoneme conversion. In addition, despite the fact that he could repeat the phonemes normally, he showed impaired performance on a version of Montgomery’s articulatory awareness task.

Just as it has been argued that phoneme awareness is a result of literacy skills, it could be argued that articulatory awareness is itself a consequence of phonological awareness or brought about by literacy skills. However, there is some evidence to suggest that this is not the case. Cary and Verhaeghe (1994) reported that illiterate adults who could not manipulate phonemic segments performed at a high level on the articulatory awareness task. This indicates that articulatory awareness does not rely on phoneme awareness nor on literacy skills.

Taken together, these findings suggest that the impairment on the articulatory awareness task is a primary deficit in dyslexia and is not a consequence of impairments in literacy and phonological awareness. However, it is not known how the deficit changes with development. Morton and Frith (1995) argue that although behavioural manifestations of dyslexia may change, the underlying cognitive impairment is life-long. This is a preliminary investigation into articulatory awareness in adult developmental dyslexics. In order to assess if the deficit persists into adulthood, participants were tested on the articulatory awareness task designed by Montgomery (1981). The subjects included in the study no longer had serious problems with reading and spelling, as indicated by their entrance to university. Therefore, in order to obtain a broader profile of their deficits, the subjects were also given a battery of phonological tasks that have shown impairments in previous studies with adult dyslexics.

METHOD

Participants

A group of 17 dyslexic and a group of 17 non-dyslexic adults took part in this study. All participants were university students with English as their first language. The mean age of the dyslexic group was 21.67 years and the mean age of the control group was 21.36 years. The dyslexic readers all had a documented history of reading difficulty and had been diagnosed as dyslexic by a clinical or educational psychologist. The control readers
had no history of reading difficulties and were recruited from the same universities.

**Psychometric and Phonological Processing tests**

Verbal and spatial reasoning ability were measured using the VESPAR (Langdon and Warrington, 1995). This includes both verbal and spatial versions of three tasks: odd-one-out, analogy, and series completion. Reading and spelling ability were tested using the wide range achievement test-revised (WRAT-R; Jastak and Wilkinson, 1984).

Participants were also given five tasks which are thought to tap aspects of phonological processing ability. One was a Spoonerism task (after Perin, 1983), where participants are presented orally with two words and are required to exchange the beginning sound of each word (e.g. ‘King John’ becomes ‘Jing Kon’). We used ten items from the spoonerism subtest of the Phonological Assessment Battery (Frederickson *et al*., 1997) and added another ten more difficult items containing consonant clusters at the beginning of the word and two-syllable words. From the same battery we used the phoneme substitution test, in which participants are presented with a word and a single phoneme and are required to replace the first sound of the word with the phoneme (e.g. ‘cat’ with a /f/ makes ‘fat’). The Naming Speed Test for objects and for digits (based on Denckla and Rudel, 1976; and after Spring and Capps, 1975) also came from the above battery. In this test participants are asked to read aloud, as fast as possible, strings of 50 digits and sets of 50 object pictures which contain five different pictures presented ten times each. Participants were also given the WAIS-III digit span subtest (Wechsler, 1998).

**The Articulatory Awareness Task**

Articulatory awareness was measured using the task developed by Montgomery (1981). Subjects were shown nine coloured sagittal sections of the human face (3 x 5 in). Each stimulus item depicted a particular constellation of tongue, teeth and lips during the articulation of a particular phoneme. The participants’ task was to identify which of the schematic drawings represented the articulation of particular phonemes (Figure 1).

On each trial, the experimenter would produce a phoneme. The participant was instructed to repeat this phoneme as many times as necessary. The experimenter watched closely to ensure that all participants could repeat the phonemes in the normal way. The participant was then asked to point to the drawing which represented that phoneme.

We used the same phonemes as those used by Montgomery (1981), rather than a systematic analysis of different contrasts. At this stage, we merely wished to establish if dyslexic adults had a deficit in the task. Because voicing cannot be represented pictorially, the voiced and voiceless consonants /t/ and /d/ were both represented by picture 4 and /s/ and /z/ were both represented by picture 6. Numbers 1 and 3 were not associated with any particular sound. The phonemes were always presented in the following order: /a/; /t/; /th/; /p/; /l/; /d/; /f/; /e/; /z/; /s/. Participants were instructed that they could select a
particular face for more than one sound, and that they did not have to select all of the faces. No time limit was given for the test.

RESULTS

Performance on Literacy and Psychometric Measures

As shown in Table 1, no significant differences between groups were found in spatial reasoning, although dyslexics showed impaired performance in verbal
reasoning \( (F(1, 32) = 8.1; p < 0.01) \). Analysis of the data from the standardized literacy tests revealed impaired performance of dyslexics compared to controls in both reading \( (F(1, 32) = 48.99; p < 0.001) \) and spelling \( (F(1, 32) = 26.60; p < 0.001) \). However, with only one exception (score of 46 on spelling test) dyslexics were within the normal range on both the reading and spelling tests (i.e. within one standard deviation of the mean).

**Phonological Processing Tasks and Articulatory Awareness Task**

The results of these tests are reported in Table 2.

Dyslexics made significantly more errors than controls on the spoonerism task \( (F(1, 32) = 6.98; p < 0.01) \). Dyslexics took significantly longer than controls to complete the digit naming task \( (F(1, 32) = 12.3; p < 0.001) \) and the object naming task \( (F(1, 32) = 6.57; p < 0.001) \). A significant difference between groups was also found in digit span \( (F(1, 32) = 26.23; p < 0.001) \). No significant difference between groups was found on the phoneme substitution task, where all of the controls and the majority of dyslexics performed at ceiling. Dyslexics were significantly

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### Table 1. Mean scores and Sds for dyslexic and control groups on standardized tests of intelligence and literacy

<table>
<thead>
<tr>
<th>Task</th>
<th>Dyslexics (N = 17)</th>
<th>Controls (N = 17)</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>21.67</td>
<td>3.18</td>
<td>21.36</td>
</tr>
<tr>
<td>VESPAR spatial reasoning test†</td>
<td>11.06</td>
<td>1.25</td>
<td>11.65</td>
</tr>
<tr>
<td>VESPAR verbal reasoning test†</td>
<td>10.82</td>
<td>1.47</td>
<td>12.00</td>
</tr>
<tr>
<td>WRAT reading†</td>
<td>97.94</td>
<td>6.46</td>
<td>113.53</td>
</tr>
<tr>
<td>WRAT spelling†</td>
<td>93.00</td>
<td>13.92</td>
<td>113.24</td>
</tr>
</tbody>
</table>

† = standard score.

Group differences significant at ** \( p < 0.01 \).

*** \( p < 0.001 \).

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### Table 2. Mean scores and Sds for dyslexic and control groups on tasks tapping phonological processing and articulatory awareness

<table>
<thead>
<tr>
<th>Task</th>
<th>Dyslexics (N = 17)</th>
<th>Controls (N = 17)</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td></td>
</tr>
<tr>
<td>Phoneme substitution (max = 10)</td>
<td>9.71</td>
<td>0.77</td>
<td>10.0</td>
</tr>
<tr>
<td>Digit span (standard score)</td>
<td>9.06</td>
<td>2.49</td>
<td>13.82</td>
</tr>
<tr>
<td>Spoonerisms (max = 40)</td>
<td>27.88</td>
<td>8.37</td>
<td>34.18</td>
</tr>
<tr>
<td>RAN digits (secs/50 items)</td>
<td>21.82</td>
<td>5.48</td>
<td>15.65</td>
</tr>
<tr>
<td>RAN objects (secs/50 items)</td>
<td>36.03</td>
<td>9.10</td>
<td>29.36</td>
</tr>
<tr>
<td>Articulatory awareness (max = 10)</td>
<td>5.06</td>
<td>1.98</td>
<td>7.24</td>
</tr>
</tbody>
</table>

Group differences significant * \( p < 0.05 \).

** \( p < 0.01 \).

*** \( p < 0.001 \).
impaired on the articulatory awareness task \(F(1,32) = 12.88; p < 0.001\). The
distribution of the scores on this task for dyslexics and controls is shown in
Figure 2.

Further between groups analysis was carried out for each individual phoneme
tested. The distribution of scores for each phoneme is shown in Figure 3. Dyslexics were significantly or marginally significantly impaired compared to
controls on five of the ten phonemes tested: /th/ \(\chi^2 = 10.09; \text{df} = 1; p < 0.001\); /p/ \(\chi^2 = 4.5; \text{df} = 1; p < 0.05\); /f/ \(\chi^2 = 5.86; \text{df} = 1; p < 0.05\); /e/ \(\chi^2 = 7.56; \text{df} = 1; p < 0.01\); /z/ \(\chi^2 = 3.36; \text{df} = 1; p = 0.066\). This is shown in Figure 3.

**DISCUSSION**

Adult dyslexics were impaired on the articulatory awareness task. Taken together
with previous findings that dyslexic children are impaired on this task
(Montgomery, 1981) we conclude that an articulatory awareness deficit can
persist into adulthood, even when literacy skills are no longer seriously impaired.
The persistence of the deficit despite changes in the behavioural manifestations
of the disorder suggests that this may be part of a cognitive deficit that underlies dyslexia.

Results from the battery of phonological processing tasks support the findings of previous studies with adult dyslexics (e.g. Paulesu et al., 1996; Brunswick et al., 1999) that phonological processing difficulties persist even when literacy skills are in the average range. However, a ceiling effect was found for both groups in the phoneme substitution task which makes the finding difficult to interpret but shows that the dyslexic adults had at least some basic phoneme awareness skills. This may have been a result of their literacy training, and ability to use an orthographic strategy.

The important finding that illiterate adults who show impaired phoneme awareness but perform at a good level on the articulatory awareness task (Cary and Verhaeghe, 1994) indicates that neither literacy nor normal phonological awareness are in themselves necessary for intact articulatory awareness. One possibility is that an intact phonological processing system is necessary to perform both articulatory and phonological awareness tasks. In addition, we would have to assume that knowledge of orthography is necessary for performance on the phonological awareness tasks, but not for performance on the articulatory awareness task. A more systematic analysis of a range of phonemes and the pattern of errors associated with different phonemes is required in order to provide more information about the processes involved in the articulatory awareness task.

The present findings confirm the robust evidence that the phonological processing deficit persists into adulthood in dyslexia, even when there are no longer major deficits in reading and spelling. The finding that the articulatory awareness deficit also persists into adulthood raises new questions about the specific nature of the speech processing deficits that underlie the disorder.

ACKNOWLEDGEMENTS

This work was supported by MRC programme grant No. G9716841.

References


