When reading is “readn” or somthn. Distinctness of phonological representations of lexical items in normal and disabled readers

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This paper specifies nothing less than an underlying cause of dyslexia. It is a cause which may be responsible for lacking responsiveness to both the teaching of phoneme awareness and to initial reading instruction. Can a single phonological factor explain many of the phonological deficits related to dyslexia? In this paper it is suggested that the answer may be affirmative and that indistinct phonological representations of lexical items in long term memory may be such a unifying factor. Results are summarised from a correlational study of adults and from a longitudinal and intervention study of at-risk children.

Key words: Reading disabilities, dyslexia, linguistic bases, phonological representation, prediction, prevention.

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DISTINCTNESS OF PHONOLOGICAL REPRESENTATIONS

Problems in establishing ‘complete’, ‘full’, ‘clear’, or ‘precise’ phonological representations in long-term memory have frequently been mentioned as a possible unifying cause of the diverse phonological difficulties characteristic of dyslexia (Constable et al., in press; de Gelder & Vroomen, 1991; Fowler, 1991; Katz, 1986; 1996 Snowling et al., 1988; Swan & Goswami, submitted). Arguably, poor phonological representations may be a cause of both difficulties with phonological discrimination, picture naming, phonological STM, and phonological awareness (Elbro, 1996; Fowler, 1991). However, supportive evidence has been scattered and suggestive. Neither has the notion of ‘imprecise phonological representations’ been made clear at all.

Distinctness of phonological representations is brought forward here as a useful working concept (see Elbro, 1996, for more details). Distinctness refers to the magnitude of the difference between a representation and its neighbours. For example and pronounced [ænd] (full form, as in “the most frequent word is and”) is more distinct than [an] (reduced form, as in “Peter and Lynette”), because [an] is indistinguishable from the pronunciation of unstressed an.

In terms of a structural theory of phonological representation, distinctness may be measured by the number of features that distinguish a representation from its neighbours. Phonological representations with many distinctive features are, on average, more distinct than representations with fewer distinctive features.

A central assumption of the distinctness hypothesis (Elbro, 1996; Elbro et al., submitted) links distinctness to completeness (and accuracy) of phonological representa-
First, preschool children who later develop reading difficulties have shown to possess relatively low levels of phonological and phonemic awareness (e.g. Catts, 1991; Lundberg et al., 1980; Mann & Liberman, 1984). Such difficulties with awareness of speech sounds may be caused by indistinct phonological representations. While a phonological representation may contain sufficient information to produce and identify a particular word, the same representation may be too indistinct for easy access to sublexical units (Elbro, 1996).

Second, even access to whole word phonology may be impeded by indistinct phonological representations. It seems reasonable to assume that it is easier to get access to a phonological representation that is well specified and clearly separated from its neighbours than to a phonological representation that is incompletely specified and less well separated from its neighbours. In this way, the distinctness hypothesis may also account for the naming speed deficits observed in association with dyslexia (e.g. Katz, 1986, 1996; Bowers & Wolf, 1993).

Third, low phonological distinctness may also be linked to phonological processing in early reading in a more direct manner. During the initial phases of reading development, the child must internalise writing-to-sound correspondences only a small proportion of which are taught directly. The child has to learn implicitly many letter patterns, such as -ight or -tion, i.e. letter strings which are pronounced in the same way in several words but which are pronounced rather unpredictably given the single letter sounds. If such implicit learning is to take place, the child must have access to the segments of spoken words which correspond to the letter strings that form the “letter pattern”. And this is where distinctness of phonological representations comes in. A child with indistinct phonological representations will have a smaller chance than other children of automatically setting up such complex letter-sound-correspondences, simply because the sublexical “sound patterns” are not easily accessible.

The following studies were set up to explore the relationships between, in particular, phonological distinctness, phonemic awareness, and reading development in normal and dyslexic persons.

STUDY 1. DISTINCTNESS OF PHONOLOGICAL REPRESENTATIONS IN DYSLEXIC ADULTS

Distinctness of phonological representations was studied in dyslexic adults by means of measures of both receptive and productive language abilities. The study has previously been reported by Elbro et al. (1994) with an additional discussion of the definition of dyslexia in adults by Elbro (in press). The present summary focuses only on the tasks which were tapping distinctness. It is based on the data from the 1994-study with the addition of some adults who have been interviewed at a later point. The participants were 121 adults with a history of difficulties in learning to read and with present problems in phonological coding in reading (non-word reading). They were compared to 62 normal controls (spouses of the dyslexic adults). The average age was 36 years (range 24 to 56 years). The educational level was approximately two years higher in the control group than in the dyslexic group, but the average educational level across both groups was close to the population mean.

Two vocabulary tests were used: one taxing semantic word knowledge and one taxing phonological word knowledge. In the semantic test subjects heard a spoken word and were asked to point to the correct one out of three pictures of objects from the same semantic field (e.g. ‘kayak’, ‘canoe’, and ‘dinghy’). In the phonological test subjects heard a spoken word or a phrase and were asked to select a synonym from a choice of three similarly sounding spoken words (e.g. ‘capital punishment’, is that the same as ‘execution’, ‘execution’, or ‘excavation’?). No printed words were shown.

In another task, the adults were asked to pronounce printed words as they would do if reading to their children. The words were embedded in real sentences, they were polysyllabic and each contained a syllable which could be pronounced correctly at different levels of distinctness, e.g. with a full vowel [plætnɪm] (an over-distinct pronunciation of platinum), with a long consonant [plætnɑm], or entirely without the syllable [plætn]. Details of the tasks, their administration and scoring are given in Elbro et al., 1994.

The dyslexic adults were outperformed by the normal readers in all tasks (Table 1). The differences between groups were still significant even when covarying for differences in education and daily reading practices. So even though the dyslexic adults had some difficulties in reading the words in the pronunciation tasks, they tended to pronounce the target words at a slightly lower level of distinctness. Furthermore, a very robust interaction was found between the two word knowledge tests and the two groups (F(1,181) = 32.9, p < 0.001). This interaction was still significant even after covarying for educational level, daily

Table 1. Linguistic abilities in adults with both self-reported reading difficulties and non-word reading difficulties, compared with normally reading adults with no history of reading difficulties. Mean scores are presented with standard deviations in parentheses.

<table>
<thead>
<tr>
<th>Reading status</th>
<th>Dyslexia (N = 121)</th>
<th>Normal (N = 62)</th>
<th>Significant F(1,181)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word knowledge, semantic (max 21)</td>
<td>17.6 (2.1)</td>
<td>18.5 (1.6)</td>
<td>9.0***</td>
</tr>
<tr>
<td>Word knowledge, phonetic (max 19)</td>
<td>12.4 (2.6)</td>
<td>15.6 (1.8)</td>
<td>74.1***</td>
</tr>
<tr>
<td>Distinctness of pronunciation (max 8)</td>
<td>2.30 (2.04)</td>
<td>3.82 (2.56)</td>
<td>9.4**‡</td>
</tr>
</tbody>
</table>

‡N = 86, **p < 0.01, ***p < 0.001.
reading practices, and phonological awareness. This interaction and the simple group comparisons suggest that the dyslexic adults were specifically impaired as to the distinctness of phonological representations.

Since the study did not include any longitudinal data, it is not possible to make inferences about cause and effect. Indistinct phonological representations may be a cause of reading difficulties, but the opposite may just as well be the case. In order to rule out the possibility that differences in reading were the sole cause of differences in phonological distinctness, a prospective longitudinal study was conducted.

STUDY 2. POOR PHONOLOGICAL REPRESENTATIONS PREDICT DYSLEXIA IN CHILDREN

The development of language and reading abilities were studied in children of the families with dyslexia (see Study 1) and in control children from families without dyslexia. Presently, we have followed a total of 159 children (87 at-risk children and 72 controls) from the onset of the kindergarten grade, when children are on average six years old in Denmark, until the beginning of the second grade (two years later). Study 2 was concerned with the early prediction of reading difficulties in these children. A report based on the older half of these children is published by Elbro et al. (1998) and some of the results below are from this report.

At the onset of the kindergarten grade, several tests of language abilities, pre-reading abilities, and two general tests of cognitive abilities were administered to the children. Among the language tests were tests of phoneme awareness, syllable awareness, and morpheme awareness in addition to tests of phoneme discrimination, verbal short term memory (digit span from WISC-R), lexical access (picture naming), and articulatory fluency (repeat “ba-ga-da” as quickly as possible). In an attempt to tap the quality of phonological representations as directly as possible, a new task was developed for this study. In this task the child was invited to take the role of a speech therapist. The child was shown a hand-held puppet and asked to help the puppet pronounce words correctly. On behalf of the puppet the experimenter named pictured objects at a very low level of distinctness, e.g. “codi” for crocodile. The puppet was even said to be hard of hearing so that the child had to be careful to pronounce the words very clearly for the puppet. The children’s responses were scored for accuracy (percent conventional pronunciations), distinctness (based on selected vowel segments, e.g. the unstressed vowels in crocodile) and proximity to orthography (see Elbro et al., 1998, for details of items, procedure and scoring).

At the beginning of the second grade, the children were given a number of reading tests, among which were two tests of phonological recoding (reading of pronounceable nonwords). Similarly to the definition of dyslexia in adults (see Elbro et al., 1994; Lyon, 1995) a cutoff definition of dyslexia was employed for the children based on averaged z-scores across the two reading measures. Children were considered possibly dyslexic if they scored below the tenth percentile in the not-at-risk group.

Analyses of variance indicated that all language measures in kindergarten were significant predictors of possible dyslexia, whereas non-verbal IQ (Raven’s progressive matrices) did not predict dyslexia. A series of logistic regression analyses were conducted in order to isolate measures that contributed independently to the prediction of dyslexia. Three measures were found: letter knowledge (naming letters), phoneme awareness, and distinctness of phonological representations. This result suggests that distinctness of phonological representations contributes independent variance to the prediction of dyslexia over and above the contribution of the standard predictors. And it is noteworthy that the inclusion of articulatory fluency and lexical access (measured in a picture naming task) did not explain away the contribution of the distinctness measure to the early prediction of dyslexia. In sum, it appears that variation in distinctness of phonological representations does in fact contribute to the prediction of early reading development.

STUDY 3. UNDER SPECIFIED PHONOLOGICAL REPRESENTATIONS PREDICT DEVELOPMENT OF PHONEME AWARENESS IN THE KINDERGARTEN GRADE

A number of studies have indicated that dyslexia may to some extent be prevented in kindergarten through activities that require phoneme awareness (e.g. Borstroom & Elbro, 1997; Brady et al., 1994; Byrne et al., 1997; Gillam & van Kleeck et al., 1996; Lundberg 1994; Torgesen et al., 1994). Children who would otherwise develop initial reading skills only very slowly appear to get a more smooth transition into literacy when they are made aware of some of the speech segments of phoneme size before the first grade. Consequently, a next goal for research in prevention of dyslexia would be to predict which children will be “resistant” to early training of phoneme awareness. Such a goal also fits well with the search for the roots of the development of phoneme awareness.

In pursuit of these goals we conducted a training study with a randomly selected subgroup of the children of dyslexic families (from studies 1 and 2). Thirty-six of the at-risk children (from 27 different classes) participated in an intensive 17 week program in their regular kindergarten classes designed to help them improve in phoneme awareness. Two control groups consisted of 52 untrained at-risk children (from 44 different classes) and 48 untrained not-at-risk children (from 7 classes). Training effects were found in phoneme awareness and in letter knowledge with positive
long term effects on reading of both words and nonwords (Borstrom & Elbro, 1997).

Individual gains in phoneme awareness over the kindergarten year were computed as a simple sum of scores in the phoneme identification and phoneme deletion tasks. And correlation analyses indicated that the individual accuracy of phonological representations of lexical items was a significant predictor of gains in phoneme awareness in both trained at-risk children and in normal controls (r = 0.55 and r = 0.44, respectively, p < 0.001 for both). The gains in phoneme awareness in the untrained at-risk children were too small to provide reliable individual differences. The correlations in the two other groups remained significant even when other significant predictors were controlled for (Elbro et al., submitted). Awareness of larger sublexical units (syllables and morphemes) did not predict gains in phoneme awareness.

These results suggest that the quality of phonological representations may indeed set the stage for the development of phoneme awareness that is so important for learning to read. While accuracy of phonological representations was found to be a significant predictor in this study, distinctness of phonological representations seemed to be the more important predictor of dyslexia (Study 2). While the two measures of phonological quality are certainly not one and the same, we suggest that they are strongly related.

DISCUSSION: THE PHONOLOGICAL DISTINCTNESS HYPOTHESIS

As mentioned in the introduction, accuracy and distinctness may be seen as two ends of the same scale. Words represented at very low levels of distinctness are under specified which means that they are likely to be mispronounced and confused with other, similar sounding words. Conversely, variation at high levels of distinctness will typically result in pronunciations within the normal range of variation, yet not all at the most distinct level.

The distinctness hypothesis (Elbro, 1996; Elbro et al., submitted), proposes that the distinctness of a lexical representation is a determinant, among others, of the accessibility of sublexical phonological units of the representation. With respect to individual variability, the distinctness model suggests that the level of distinctness of phonological representations of lexical items vary within individuals and between individuals. As a consequence, some children may possess an age-appropriate vocabulary and be able to pronounce and perceive words fairly normally, but still have problems with tasks that require access to sublexical units. These children will also be unlikely to be able to pronounce the same words at varying levels of distinctness to meet the demands of changing conditions of communication and changing listener characteristics.

So far however, studies of the quality of phonological representations are scarce. In-depth case studies might be one way to proceed in order to map the detailed relations between words represented at varying degrees of distinctness—and the ease of access to their sublexical units. Training studies would also be needed for a more direct test of the claim that low distinctness is an underlying cause of difficulties in the development of phoneme awareness. Finally, and most ambitiously, converging evidence should be sought across languages and educational systems.

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REFERENCES


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