PHONOLOGY WITHOUT ORTHOGRAPHY AND THE EXTENT OF THE PHONOLOGICAL DEFICIT IN DYSLEXIA

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1. Introduction

It has been hypothesised that developmental dyslexia is caused by an impairment in individuals' phonological representations, which has a knock-on effect on their literacy acquisition. This paper begins with a discussion of the links between literacy and language, then goes on to outline one method for sidestepping these links in order to test phonological representations independent of any possible input from a speaker's literacy knowledge. The results of a pilot study which implemented this method are then reported, and the paper concludes with a discussion of the implications for the phonological representations hypothesis.

2. The links between language and literacy

Linguists are usually at great pains to distinguish between spoken language and written language. Spoken language has primacy both historically and ontogenetically, and written language is usually assumed to be nothing more than a reflection on paper of the sounds of language and/or of the representations of those sounds in the minds of language users. There is a firm dividing line between the field of spoken language analysis on the one hand and written text analysis on the other, and issues of text and literacy are not usually treated as relevant in the analysis of spoken language (see, Pinker (1994) for a recent example and the historical position as shown in the citations from de Saussure, Bloomfield, Jakobson, and Hockett in Vachek (1989: 18-19)).

However, by assigning too much importance to the separateness of spoken language and written language, we run the risk of overlooking the possibility that there is a two-way relationship between language skills and literacy skills, such that people's language knowledge and acquisition are influenced by the literacy conventions which their society uses and which they themselves acquire. The relevance of this possibility in the present context is that if phonological knowledge is even partly the result of becoming literate in a given orthography, then deficits in phonological knowledge may be at least partly the result of lack of success becoming literate, rather than the other way round.

Evidence for a two-way relationship between language and literacy comes for example from the study of children's early spellings. Treiman's (1997) investigation of early spellings suggested that children's departures from a word's conventional spelling were based on acoustically highly plausible alternative analyses of the sounds in those words (eg analysing the start of *dry* as an affricate rather than a sequence of stop plus approximant, and the end of words such as *her* as consisting of a rhotacised vowel rather than a sequence of vowel plus approximant). She argued that the process of learning to read reshapes children's spontaneous analyses of the sounds of words, so as to match the conventional spellings:

> "As children see that this sound [in the word *dry* eg] is always spelled with 'd', their classifications change. … Orthography, originally learned as a representation of speech, takes on a life of its own and begins to influence children's views about the language itself." (1997: 200)

Her analysis suggests that a person's idea of spoken language is something that is shaped by the process of becoming literate.

Further evidence for the difference that literacy makes to language can be seen in adults who are non-literate, or who are literate in a non-alphabetic script. Morais et al (1979) administered phoneme deletion and phoneme addition tasks to illiterate adults in Portugal, and found that they had great difficulty performing the tasks, compared to a control group of literate adults. Subsequent studies extended these findings. Read et al (1986) compared two groups of Chinese adults, one in which participants were literate in the traditional syllable or morpheme based script, and one which participants were also literate in the alphabetic pinyin script, and they found that the participants were only able to carry out phoneme manipulation tasks if they were alphabetically literate. Prakash et al (1993) also corroborated these findings in studies with participants who were literate in Kannada, which is semi-alphabetic, and those who were also literate in English, and found that only those who had alphabetic knowledge did well in phoneme segmentation tasks. Studies such as these show that literacy experience has a significant influence on people's language knowledge – phonological awareness, as measured by the phoneme manipulation tasks, is to a large extent modulated by the kind of shape which the individual's orthography moulds spoken language into.

Thirdly, this filtering of spoken language through the conventions learned for written language can be seen in literate societies in a variety of everyday ways. Derwing (1992) gives a number of instances of orthographic knowledge influencing people's perception of the sounds of words, including the finding that people think there are more sounds in the word *pitch* than in the word *rich* (Ehri & Wilce 1986) – since the rhymes of these words are identical in terms of sound, the belief that one 'has more sounds' than the other can only come from the way they are spelt. Treiman and Danis (1988) also found that intervocalic consonants are only perceived to be ambisyllabic if they are geminate in orthography. Derwing (1992) presents data about phoneme deletion skills in fully literate adults when they are presented with words that do not have a one-to-one mapping of phonemes to letters – if people are asked to delete the "b" from *basket*, they find it much easier than if they are asked to take the "k" out of *taxi*.

These demonstrations of the links between spoken language and literacy have some serious implications for the way we conceptualize language competence in general, and in particular the phonological abilities of individuals with dyslexia. This point will be expanded in the following section.

3. The place of phonology in dyslexia resesarch
Dyslexia is a specific learning disorder, characterised by reading and spelling difficulties which are out of step with the person's abilities in other areas. Typical definitions are phrased in terms of "an unexpected, specific, and persistent failure to acquire efficient reading skills, despite conventional instruction, adequate intelligence, and sociocultural opportunity" (Demonet, Taylor & Chaix 2004: 1451). Some definitions also mention a deficit in writing skills (Royal College of Speech and Language Therapists 1990) or spelling (British Psychological Society 1999).

One reason why phonology has been implicated in dyslexia is because of findings that deficits in phonological awareness persist into adulthood, when other deficits are less obvious. Pennington, van Orden, Smith, Green and Haith (1990) compared the phoneme awareness skills of dyslexic and non-dyslexic adults by administering a pig latin task: participants were required to identify the initial phoneme of the presented word (which was either one or two syllables long, controlled for initial singletons, clusters, and digraphs), and

then say the word with the initial phoneme removed from the onset and placed instead at the end of the word as the onset of a new syllable with the rime /e/. For example, *blow* /blo/ becomes /lo-be/. Pennington et al described this as a difficult task, designed to uncover deficits which would not be so evident if adults were given easier phonological awareness tasks such as syllable counting. The increased demands from the phonological point of view included segmentation and blending skills, although it should also be noted that the mental manipulation of the identified units places quite significant demands on working memory too. Additionally participants were required to recognise the pig latin form of a second set of words, which was less demanding. It was found that on both tasks, the scores of the dyslexic participants were significantly lower than both reading age and chronological age controls, and this persistence of the phonological awareness deficit into adulthood was put forward as an indicator that it is a primary symptom of dyslexia. The Pennington et al (1990) finding has since been corroborated by several studies: by Bruck (1992) using syllable counting, phoneme counting, and phoneme deletion tasks (dyslexic children and adults had poorer phonological awareness scores than their reading age and chronological age controls); by Gottardo, Siegel and Stanovich (1997) using syllable deletion, phoneme deletion, and a pig latin task (phonological awareness was found to be a consistent and unique predictor of reading ability); and also by Gregg et al (2002) using a comprehensive battery of phoneme and syllable counting and segmentation tasks (university students do not acquire expected levels of phonological knowledge regardless of their age or reading level).

Perception data has also been brought forward to support the suggestion that dyslexic phonological representations are impaired. Mody, Studdert-Kennedy & Brady (1997) found that 7-9 year old dyslexic children were less consistent than controls in phoneme identification when the stimuli were synthetic /ba-da/ and /da-ga/ syllables, although like controls they made no errors on /ba-sa/ or /da-Sa/ identification. Mody et al suggested therefore that phonological storage is coarse-grained in reading-impaired individuals: phonological categories are broader and less well separated in reading-impaired individuals compared to normal readers. The difficulties with identifying /ba-da/ were said to arise from difficulty identifying the phonological categories which phonetically similar speech sounds belong to: "poor readers cannot easily exploit the phonological contrast that normally enhances discrimination across a phoneme boundary" (1997:201). The notion of contrast is also invoked by Adler and Hazan (1998), who presented thirteen dyslexic children (aged between 9;3 and 11;7) with minimal pairs to judge as same/different. About a third of the children in their sample had phoneme discrimination difficulties relative to chronological age and reading age controls, and they comment that the degree to which consonant contrasts are maintained differs not only from consonant to consonant, but also depends on the vowel context in which the consonant appears.

Taking together pieces of evidence such as these, some researchers have suggested that there may be an impairment in the phonological representations of individuals with dyslexia, and further, that the phonological impairment is the underlying cause of the literacy difficulties seen in dyslexia. This view is known as the Phonological Representations Hypothesis (Snowling 2000) (or the phonological deficit hypothesis). Under this view, individuals with dyslexia have "a pervasive problem at the level of underlying phonological representations" (2000: 44), characterised by a "lack of phonological specification" (2000: 43), or more particularly, by lexical representations which may not be organised into phonemic segments (2000: 43).

This hypothesis is a potentially useful concept in that it links clinically observed deficits with linguistic theory: it attempts to explain the observed deficits by appeal to theoretical constructs. However, the focus of the present discussion is on the assumption that

difficulties with doing segment-based tasks must reflect impairments in people's language abilities. In the light of the overlap which exists between literacy and segmentation, we cannot simply conclude that a deficit in phonological segmentation or manipulation ability must be a purely phonological problem. If the ability to manipulate phonemes is facilitated by and/or dependent on the ability to manipulate letters, we cannot conclude that phonological segmentation deficits must be the source of written language deficits. For example, if the identity of a phoneme is partially determined by the letter or letters which represent it, then testing subjects' ability to categorise ambiguous phonetic information as instances of one phoneme or another is confounded by orthography – the ability to categorise sounds into phoneme-shaped distributions is aided by becoming alphabetic (Ehri 1993: 39). The possibility remains that all that we know about dyslexia from such studies is perhaps only tautological – the reaffirmation from a different perspective of something we already knew, ie that people with dyslexia have impaired literacy skills. At the very least, knowing a correspondence between graphemes and their phonemes, or phonemes and their graphemes, provides the subject with a metalanguage to utilise in the categorisation of the sounds presented.

4. Phonology without orthography

The question therefore arises as to whether people with dyslexia are impaired in all areas of phonology, or only those areas which demand literacy-linked segmentation ability. Even if we acknowledge that a phonological deficit exists, as things stand, we still have no way of knowing how far this deficit extends across the whole range of phonological knowledge that a person has. So far, we only know that there is an impairment in areas of phonology which overlap with orthography. This means of course that we need to identify areas of phonology which aren't represented orthographically

In order to constitute a testing ground for the phonological representations of individuals of dyslexia, two criteria need to be met. Not only does there need to be a phonological phenomenon which is not represented orthographically, but it must also be comparable with the kinds of phonological entities (units, representations, processes) which have already been investigated in individuals with dyslexia.

Such areas are harder to find (and operationalise) than might be expected, given the professed prioritising of spoken language over written language in linguistics in general and phonology in particular. Words, morphemes, and phonemes do not meet the first criterion as they are all familiar to people who write with alphabetic letters and can see the shape of words and put spaces between groups of letters, and therefore do not escape the orthography confound (Linell 1982; Scholes 1993). Meanwhile, aspects of phonology which are not represented orthographically include voice quality, intonation, and regional accent, but these phenomena tend to be viewed as phonetic, sociophonetic, and/or pragmatic phenomena rather than strictly phonological (although see Docherty & Foulkes 2000).

One phonological phenomenon which meets both criteria is that of the stress difference between compounds and phrases such as <u>*toy*</u> *factory* 'place where toys are manufactured' (compound) versus *toy* <u>*factory*</u> 'model factory for children to play with' (phrase).This particular prosodic phenomenon has been recognized for decades as being contrastive on the prosodic level in the same way as phonemes are contrastive on the segmental level. This is how they were analysed by Daniel Jones (Jones 1967, chapter 26, especially §489), more recently by Ladd (1984), who discusses "the minimal pair *steel warehouse* / *steel warehouse*" (p. 264), and more recently still by Vogel and Raimy (2002), who state clearly that "… stress may be used contrastively in a language to distinguish meanings, as phonemes do at the segmental level" (p. 227). As minimal pairs, these items and the others

like them are the suprasegmental analogy of phoneme-based minimal pairs, which is exemplified for English in *tea* versus *key*, and *pin* versus *bin*.

Items such as "toy factory" and "steel warehouse" are always ambiguous in isolation in writing: it is impossible to tell whether it is the compound interpretation which is intended or the phrasal. In their spoken forms, however, the stress pattern is the guide to meaning. There is also a class of items which are not fully orthographically ambiguous, but which are similar to the "toy factory"-type items in that they rely on stress to distinguish them in isolation in spoken language. These are pairs such as *hotdog* versus *hot dog*, and *greenhouse* versus *green house* (the distinction is made orthographically by the presence or absence of a space between the two components).

There are several controversies in the literature about how best to characterize pairs of items such as these (e.g. Giegerich 2004, ta; Ladd 1984; Bauer 1998; Plag ta), but since my interest in these pairs is practical rather than theoretical, I am content to exploit those cases where the stress pattern provides the disambiguation, and leave the analysis to one side.[1] As a working guide, however, I am treating the first word in the pair as lexically ambiguous between an adjective and a noun, such that when the construction is phrasal it functions as an adjective, and when the construction is a compound it functions as a noun.

5. Production of stress-minimal pairs in Scottish English

Although the stress-based contrast is widely discussed in the literature, a preliminary study was undertaken in order to confirm whether there are any reliable differences between the two stress patterns in Scottish English (as distinct from Southern British English (Jones 1967) and American English (Vogel & Raimy 2002)).

One female speaker of Scottish English read out a list of prompt cards. Each card contained three sentences, two to set up a context and the third containing the item of interest. The item was located sentence-finally and all the sentences were declaratives. Each prompt card set up a syntactic pattern of three compound nouns or three adjective + noun phrases. For example, to elicit the compound reading of *toy factory*, the speaker was presented with the sentences, "This is a carpet warehouse. This is a car showroom. This is a toy factory." To elicit the phrasal reading, the sentences were, "This is a model city. This is a replica steamboat. This is a toy factory." All the compound readings were elicited prior to showing

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[1] For example, Giegerich (ta) seems to be taking two categories, compounds and phrases, and aiming to find diagnostics for what should go in which category. One of the main reasons why stress is not considered a wholly reliable diagnostic is because of cases such as *red herring*. *Red herring, blue moon, white elephant*, and others like them have end-stress or so-called "phrasal stress", but they are are identified as compounds on the basis that they are not fully productive and not semantically transparent. However, this conflict between compoundhood and stress pattern could be avoided if another analysis of these items is provided– one in which they can be recognized as being idioms, while not assuming that they are compounds. In this way they could be classified along with constructions such as *off the cuff, kick the bucket, wet behind the ears*, which are neither fully productive nor semantically transparent, and yet which are not classified as compounds. Although they are idioms, in other words, they are not necessarily compounds, and to recognise this would make the link between the syntactic category and the stress pattern more reliable.

  Bauer (1998) is also skeptical of a straightforward match between syntactic category and stress pattern, but his analysis of compounds is again open to an alternative interpretation. Although in this paper compounds are described as being indivisible lexical items, in practice it seems that the two elements which the compound is composed of are treated as if they were still separate lexical items. For example, considering the case of *blackbird*, the stress pattern which *black-* is realized with is investigated, as are the different contexts which this element appears in, in order to draw conclusions about compounds. This in effect fails to recognize the compound as a compound – it is not being treated as an indivisible unit whose components have now been compounded together such that they cannot be analysed outwith the context of the compound as a whole. However, the conclusion which is most usefully drawn for my purposes is to leave these questions as speculative, and simply take the pragmatic line that stress is relevant for my purposes simply because it is the only property which differentiates between these segmentally identical constructions.

the speaker the sentences for the phrasal readings. In this way, although the speaker was aware of the potential ambiguity, the difference between the compound and phrasal version of each item was not elicited explicitly.

There were sixteen pairs of items in total. Six of them were the *toy factory* type, ie genuinely orthographically ambiguous in isolation, and ten of them were the *hotdog/hot dog* type, ie reliant on stress for interpretation when spoken in isolation but with possible orthographic input. All the items are listed in the appendix. This gave a total of 32 items (a compound and phrasal version for each of the sixteen pairs).

The whole list of 32 items was read out three times by the speaker, giving three tokens for each of the target items (in both versions). The target items were then excerpted from their sentences for analysis. For convenience, each item is discussed below in terms of its first and second "words", so as to compare the two segmentally similar components of the compound member and the phrasal member of each minimal pair (even for the *hotdog*-type items, which of course consist of one single compound word; ie *hot-* and *-dog* in the compound *hotdog* are called Word1 and Word2 respectively even though they are not identical to *hot* and *dog* in the phrase *hot dog*).

When the compound readings were compared with the phrasal readings, two acoustic differences emerged. In the phrasal reading, both Word1 and Word2 were significantly longer in duration than their counterparts in the compound reading (means for Word1: 267 msec in compounds and 335 msec in phrases; $t = 7.272$, $p < .001$; means for Word2: 402 msec in compounds and 487 msec for phrases, $t = 8.340$, $p < .001$). In addition, in the compound reading, the pitch peak in Word1 was significantly higher than in the peak in Word1 of the phrasal reading (means 247 Hz for compounds and 229 Hz for phrases, $t = 6.809$, $p < .001$). Pitch was measured only for the first word of both versions, because at the end of the sentences, the second word was often characterised by creaky voice, making pitch measurements unreliable.

Taken together, the acoustic analysis showed that phrases and compounds are realized significantly differently from each other, at least as produced by this speaker in this elicitation procedure.

6. Interpretation of stress-minimal pairs by non-impaired adults
Having established that compounds and phrases had different acoustic characteristics, the central question addressed by the pilot study was whether or not people could assign the correct interpretation to either member of the pair when they heard it.

A binary forced-choice experiment was used to address this question. Participants had to listen to one member of the minimal pair and choose which of two pictures showed the meaning of what they had heard.

6.1. *Materials*
The auditory stimuli were selected from the three readings elicited as described above. The three readings of each item were examined, and in each case, the first reading was selected unless there was a reason to prefer the second or third readings (eg to avoid excessive creaky voice at the end of the utterance).

Visual stimuli consisted of pictures corresponding to the two possible interpretations of each Word1+Word2 sequence. The pictures for the compound and phrasal interpretation

were then placed side by side so that for each auditory stimulus there was a choice of two pictures.

6.2. *Participants*
Twelve students were recruited to take part in the experiment, five male and seven female. Ages ranged from 19;0 to 42;3 (mean 24;6). Four reported having a Scottish regional accent. None reported any history of speech, language, or hearing impairments.

6.3. *Procedure*
Participants were asked to listen through headphones to the recording, then to select from the two pictures on the screen the one which matched what they had heard. The stimuli were presented in E-Prime. Two pairs of items were used as practice items, ie hot+dog and green+house (scores from the practice items are not included in the analysis).

Each participant heard both the compound and the phrasal version of each item. The presentation order of the auditory stimuli was randomised for each participant. The order of pictures on the screen was kept the same for a random selection of half the pairs, and varied for the other half (ie for one auditory version of the Word1+Word2 sequence the picture of the compound interpretation would be shown on the left hand side of the screen and the phrasal on the right hand side, and for the other version the order would be reversed). There was a second's interval after the participant selected the picture before the next sound was presented. Accuracy and reaction time data were collected.

6.4. *Results*
The mean score correct for the whole group was 18.9 out of 28 items, or 67% correct. A single-sample *t*-test with a hypothesised mean of 14 is significant ($t(11) = 5.515$, $p < .001$, one-tailed), which means that the subjects chose the correct response significantly more often than by chance.

There was virtually no difference between males and females in accuracy (means 17 and 20 respectively, $t = 1.9$, $p = .049$, one-tailed), and no difference in time taken to respond (means 2023 msec and 2385 msec respectively, $t = 0.9$, $p = .207$, one-tailed). Nor was there any difference between participants with Scottish accents and those with other accents, either in accuracy (means 18.75 and 19 respectively, $t = .126$, $p = .902$, two-tailed) or in time taken to respond (means 2187 msec and 2257 msec respectively, $t = .144$, $p = .888$, two-tailed).

In addition, there was no difference in the accuracy of recognising compounds compared to recognising phrases (mean number of times correctly recognised for compounds = 8.4; for phrases = 7.8, $t = .533$, $p = .603$, two-tailed). Time taken to respond to compounds was no different from time taken to respond to phrases (means 2219 msec and 2250 msec respectively, $t = .199$, $p = .846$, two-tailed).

6.5. *Discussion of the results*
Although the participants selected the correct interpretation more often than chance, it was felt that an average accuracy of 67% was not as high as it could be. For instance, Vogel and Raimy (2002) found that accuracy was as high as 85% in a similar task with a group of ten non-impaired adult speakers of American English.

There are several ways in which the procedure could be modified in order to make the task easier. In the elicitation of the contrast, speakers should be asked to read the pairs of items side by side, to make sure that the intended stress patterns are explicitly differentiated, instead of the more naturalistic elicitation procedure used above, which may have resulted

in less clearcut realisations for what is after all not a particularly salient contrast. Additionally, having the target items located sentence-finally may have introduced confounds with sentence-final prosodic patterns and made the compound/phrase contrast less clear. Locating the items in the middle of the sentence would avoid this problem. Thirdly, rather than using the target item excerpted from its sentence and played to participants in isolation, participants should hear each item in a complete sentence, to give them more prosodic information to base their decision on.

7. Further steps

At the time of presenting this paper, the changes identified above as necessary to make the task easier have been implemented. Some general methodological alterations have also been made, such as increasing the number of both types of stimuli, ensuring that there is the same number of "toy+factory" items as "hot+dog" items, and adding filler items.

A variety of different speakers have also been recorded reading out the sentences. Initial exploratory analysis of the recordings suggests that although there are some expected individual differences amongst my speakers (a variety of Scottish regional accents, and varying speech rates and pitch ranges), all speakers are consistent in the way they differentiate between compounds versus phrases. Using the slightly modified elicitation procedure (with speakers explicitly differentiating between compounds and phrases, and with the target items located sentence-medially), it appears that Word1 in compounds is both higher in pitch and longer in duration than Word1 in phrases, and that Word2 in phrases is both higher in pitch and longer in duration than Word2 in compounds, or in other words a less subtle distinction than was previously elicited.

8. Conclusion

Since stress-based minimal pairs are not distinguished orthographically, and since they have the same theoretical significance as the contrast between /p/ and /b/, they constitute a useful tool for exploring areas of phonology which do not overlap with what people know about the way that English is written.

Having piloted the minimal pairs task with non-dyslexic adults, and having identified aspects of the task which need to be modified, the next step is to investigate how individuals with dyslexia perform on a task involving this contrast. If the Phonological Representations Hypothesis is correct to argue that an underlying phonological problem is what causes dyslexia, then the dyslexic group should show a deficit relative to controls in a task such as this; and if such a deficit does appear, it will suggest that the 'phonological impairment' in dyslexia extends beyond segmental phonology right across the board (phonologically speaking) – so lending support to the Phonological Representations Hypothesis. If on the other hand the dyslexics perform to the same accuracy levels as matched controls, this will take away one major pillar of support for the Phonological Representations Hypothesis, because it will show that there needs to be an important caveat added to the current formulation of the hypothesis – it would not be possible to claim that dyslexic phonology is altogether impaired, but only in its segmental aspects.

The implications of a deficit restricted to segmental phonology would be both theoretical and practical. On the theoretical level, it could be used to lend support to the assumption that there is a division between segmentals and suprasegmentals such that one can be impaired while the other cannot, for example. On the practical level, meanwhile, a phonological deficit restricted to segmentals would remain open to all the arguments from findings about dyslexia which are external to language – such as the deficits described by

Démonet et al (2004:1452) as the "low-level visual, sensory, [and] motor coordination deficits reported in many patients" (see also the reviews in Ramus et al 2003). Finally, conceptually, it would also fail to break out of the tautology identified above – we still have no way of knowing whether a deficit in segmental aspects of phonology is anything other than the reflection of a deficit in skills related to proficiency in an alphabetic orthography.

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Appendix

Genuinely ambiguous sequences		
word1+word2	**compound interpretation**	**phrasal interpretation**
French+teacher	someone teaching French	teacher of French nationality
glass+case	place for keeping glass	case made of glass
gold+hammer	tool for working on gold	hammer made of gold
toy+factory	factory producing toys	imitation factory for children
wood+chopper	tool for chopping wood	axe made of wood
wood+plane	tool for planing wood	aeroplane made of wood

Idioms		
word1+word2	**compound interpretation**	**phrasal interpretation**
big+top	circus tent	large spinning top
big+wig	important official	large wig
blue+bottle	type of insect	bottle coloured blue
bulls+eye	target of darts board	eye of a bull
green+house	glass enclosure for growing plants	house which is green in colour
head+hunter	employment agent	leader of hunting group
hot+dog	sausage snack	dog which is hot
red+neck	derog ref to southern US	neck with red colour
tall+boy	chest of drawers	boy who is tall
tight+rope	circus act	rope pulled taut