The relationship between lexical and non-lexical processes in spelling

Thesis

The Relationship between Lexical and Non-Lexical Processes in Spelling

Rae Sibbitt, B. Sc., M. Sc.

Author number: M7027058
Date of submission: 25 March 1991
Date of award: 27 September 1991

Thesis submitted in partial fulfilment of requirements for the degree of

Doctor of Philosophy in Cognitive Science

The Open University

February 1991

Abstract

Research into children's spelling difficulties has generally focussed on the kind of errors children make, categorising them as 'phonetic' or 'non-phonetic'. These errors are then interpreted within the framework of the 'dual-route' model of spelling. Although this model can account for phonetic errors, the explanation of non-phonetic errors is inadequate. The first half of this thesis investigates the hypothesis that children use non-phonetic phoneme-grapheme mappings to produce non-phonetic spellings. In order to examine these mappings, three studies were carried out to look at children's spelling of nonwords. The first compares the spelling of vowel phonemes in nonwords and real words; the second compares the spelling of vowel phonemes by children with and without spelling difficulties and the third shows how a corpus of nonword spellings can be used to identify problematic phoneme-grapheme mappings.

In the second half of the thesis, it is suggested that nonwords are not simply spelt using phoneme-grapheme mappings, but that lexical information in the form of morphemes may also be used. Three experiments are described. The first is a phoneme-classification task used to test for the activation of morphemes in the lexicon; in the second and third experiments (carried out on adults and children respectively) nonwords are presented in priming and non-priming contexts to test for the effect of higher level information on the use of morphemes in nonword spelling. The results suggest that not only can morphemes be used in spelling nonwords, but their use can be influenced by the context in which the nonword is presented. It is proposed that the dual-route model should be modified in order to allow for interaction between the lexical and non-lexical routes in nonword spelling, and to allow for the influence of syntactic information on this interaction.

Acknowledgments

I would like to give a big hearty thank-you to my Ph.D. supervisors, Di Laurillard, Claire O'Malley and Helen Pain, for doing such a good job. I would also like to thank Tim O'Shea for his comments on the first draft of the thesis and for his helpful advice over the last 3 years. Thanks to Dave Perry for his hardware support, and to all the research students and staff in I.E.T. for making it the perfect place to do a Ph.D. I will certainly miss you.

Thanks to Jenny Raffan for inspiring me to do research in this field and for arranging access to children in Exeter. Thanks also to the teachers and pupils of Cedars Middle School, Lovat Middle School and Springfield "Do you actually get PAID for doing this?" Middle School for their enthusiastic participation in my nonword experiments. I would like to thank Hank Kahney for allowing me to carry out an experiment at Summer School, and Chris Barry, Phil Seymour, Uta Frith and John Richardson for their comments on my work. Thanks to Ruth Campbell for lending me her data and for her comments.

I would like to thank Simon "Do you want to come for a ride in the van?...Aw, come on" Nuttall, Roshni "Go home, Sibbitt" Devi and Richard "I've got a new joke" Joiner for creating the perfect intellectual atmosphere, and for their enthusiastic participation in the design and execution of numerous work-avoidance schemes. Thanks to my Ph.D. role model, Anne-Marie Barron, for reminding me that Ph.D. stands for 'Plodding Hevery Day' and to Tim Rajan for persuading me not to give up.

Most of all I would like to thank John "It's only a Ph.D. for God's sake" Domingue for his unstinting support and encouragement, and for taking me to Mauritius. Thanks to Mum and Derek and Dad and Pauline for parental guidance, and to Dad for having the final draft copied and bound.

This research was funded jointly by Rank "Don't spend it all at once" Xerox and the Open University.

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CHAPTER 1

Introduction

1.1 Motivation

In an influential handbook written largely for teachers, Schonell and Wise (1985) outline the importance of accurate spelling:

> 'Writing should be a precise and satisfying means of communication, in which a child is capable of expressing his ideas accurately and coherently.' (p. 7)

The ability to spell correctly contributes to both academic performance and to self-esteem (Thomson and Hartley, 1980). However, despite the same teaching as their peers and average-to-high intelligence, some children fail to learn how to spell accurately. These children experience not only a lack of academic fulfilment, but a profound sense of personal failure which in turn affects their ability to learn the very skills which eluded them in the first place. Although much research has focussed on children's reading difficulties, there has been comparatively little research into children's spelling difficulties until recently (see Frith, 1980; Henderson and Beers, 1980; Ellis, 1984; Ellis, 1985; Read, 1986; Snowling, 1987), when it was generally acknowledged that spelling is not simply the reverse of reading, and we should not expect children to pick it up automatically. The aim of this thesis is to explain some of the problems in spelling that these children experience.

1.2 Background

Research into spelling has been carried out within the framework of the 'dual-route' model. According to the dual-route model (Ellis, 1982), there are two main processes which can be used in spelling: these are the 'lexical route' and the 'non-lexical route'. The first involves accessing the spelling of a whole word, stored in the 'lexicon'; the second involves segmenting the word into its constituent phonemes, and spelling each phoneme separately using phoneme-grapheme mappings[1]. This is called the 'non-lexical' route. Whereas the lexicon can be used to spell real words, nonwords have to be spelt using the non-lexical route (Shallice, 1981).

Using this model, research into children's spelling has focussed on the kind of spelling errors children make (e.g. Boder, 1973; Treiman, 1984). Spelling errors are categorised as being either 'phonetic' or 'non-

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[1] Throughout the thesis, the terms 'phoneme' and 'grapheme' are used to represent the linguistic units of processing in the non-lexical route. A 'phoneme' refers to an individual unit of speech which can be articulated but which can not be reduced further to any articulable sound. Phonemes and phoneme strings in this thesis are represented by the symbols of the International Phonetic Association (Jones, 1972). A full list of the phonetic symbols is given in Appendix A. A 'grapheme' refers to the letter or letters which are commonly used to spell a phoneme. This is a definition used by Coltheart (1978) in the study of reading, although other definitions have been proposed (see Henderson (1986) for a discussion of the validity of the term 'grapheme' as a linguistic concept).

phonetic'. A 'phonetic' error is one which reads back as the intended word (e.g. 'want' spelt 'wont') and a non-phonetic error is one which does not read back as the intended word (e.g. 'television' spelt 'tahgfring'). If a child makes mostly phonetic errors on real words, but can spell nonwords, it is concluded that their lexical route is impaired but they can still produce plausible spellings for real words and nonwords using the non-lexical route. Because English is not a strictly phonetic language (unlike, say, Italian or Hawaiian), errors may easily be made on real words if the non-lexical route is used. If a child makes mostly non-phonetic errors on real words, and cannot make up plausible spellings for nonwords, it is concluded that both their lexical and non-lexical routes are impaired. Thus we can see that phonetic mis-spellings are explained as the child being over-reliant on the non-lexical route, but the child's generation of non-phonetic spellings can not be explained. This thesis sets out to explain how children may make non-phonetic spelling errors.

In this thesis it is proposed that non-phonetic errors are made as a result of the child using non-phonetic phoneme-grapheme mappings in the non-lexical route. A recent study by Barry and Seymour (1988) showed that when adults use the non-lexical route to spell nonwords, they select the 'highest contingency' phoneme-grapheme mappings to spell each phoneme. This means that the mappings they use are the most common sound-to-spelling mappings found in English. Presumably, since we are not generally taught the most common spellings of individual phonemes, the mappings in their phoneme-grapheme grammars were derived from the orthographic representations in the lexicon. Assuming that they were literate, we may expect that the contents of an adult's lexicon constitute a representative subset of English words. Thus, the spellings they produce for nonwords are likely to be phonetically accurate.

However, since children are still learning to read, they may have an unrepresentative set of words in their lexicon. Due to the non-phonetic spellings of many English words (e.g. 'yacht', 'women'), phoneme-grapheme mappings abstracted from this set of words may be non-phonetic themselves. In addition to this it is possible that words may have been learnt wrongly so that incorrect spellings are also stored in the lexicon. The first three studies in this thesis investigate the phoneme-grapheme grammars of children with spelling difficulties by examining how they spell nonwords.

From these studies, it appeared that some children were also using morphemes in their spelling of nonwords. Some morphemes have non-phonetic spellings, such as the plural noun morpheme 's' which is frequently pronounced like the letter 'Z' (as in 'dreams') rather than the letter 'S'. This is because the function of these morphemes is to convey syntactic, rather than phonetic, information (Baker, 1980). Morphemes are thought to be stored in the lexicon (Morton, 1980). If this is the case, and they are being used in nonword spelling, it can be concluded that lexical information is being used in what was thought to be a non-lexical process. The two routes of the dual-route model may therefore be even more interactive than was previously thought. The last three experiments examine the use of morphemes in adults' and children's nonword spelling.

1.3 Research methodology

In order to investigate phoneme-grapheme grammars, the first three studies look at children's spelling of nonwords. This is because, from the dual-route model, it was expected that only the non-lexical route would be used. The analyses in these studies are largely qualitative, although statistical analysis is used in Chapter 4. However, from the data collected in these three studies, it appeared that lexical information (in the form of morphemes) can also be used in nonword spelling. An experimental framework was therefore adopted for the research described in Chapters 6, 7 and 8, in order to establish scientifically whether or not such information was actually being used.

Analysis of variance (ANOVA) is the main statistical technique performed on the data in this thesis. The robustness of this technique is generally accepted (see Glass, Peckham and Sanders, 1972), particularly when sample sizes are equal. Other tests used were Student's t-test, correlations and Chi-squared. Details of all the statistical procedures included within this thesis can be found in Winer (1971).

1.4 Outline

Research which is related to the work reported in this thesis is described in Chapter 2. Here the reader is introduced to the dual-route model of spelling, and the functioning of the lexical and non-lexical routes in spelling words and nonwords. This chapter reports evidence for the dual-route model, some of which is drawn from research into the spelling of different kinds of words (regular vs. irregular words and real words vs. nonwords). Other evidence is described which is based on the study of adults with brain damage whose spelling has been impaired as a result of the injury - these patients are referred to as having 'acquired dysgraphia'. Finally, the chapter shows how the dual-route model has been used to account for children's spelling difficulties, and how it fails to explain non-phonetic spelling errors.

The rest of the thesis consists of two main investigations. Chapters 3, 4 and 5 examine how children with spelling difficulties spell nonwords. Chapters 6, 7 and 8 investigate the use of morphemes in nonword spelling.

Chapter 3 describes the first study which was carried out. This study aims to show that graphemes used in nonwords are derived from the spellings of real words stored in the lexicon. It does this by comparing the spelling of vowel phonemes in nonwords and rhyming real words, by children with spelling difficulties. It is found that the children are fairly consistent in their use of graphemes in nonwords and words which they know. However, since it was possible that the real words themselves were also spelt non-lexically, it was decided that future studies in this thesis should concentrate solely on nonword spelling.

The following study, described in Chapter 4, looks exclusively at how children with spelling difficulties spell vowel phonemes in nonwords, and compares their performance to a control group of children who do not have spelling difficulties. By presenting the same vowel phoneme in a number of different nonwords, the study demonstrates that the children with spelling difficulties were not less consistent than the control group in the phoneme-grapheme mappings they select for nonwords, but that they used mappings which were less like English phoneme-grapheme mappings than those used by the control group.

Chapter 5 describes a study in which a corpus of nonword spellings are collected from children with spelling difficulties. In this study, each child spells a particular vowel phoneme in at least 170 nonwords. Using this amount of data it is possible to identify problems that a child might have with particular phonemes, the consistency with which a child uses a particular grapheme to spell one phoneme and whether a child is sensitive to the different spellings of a phoneme when it occurs in different positions within a word. The data from three children are reported as case studies.

Chapters 6 and 7 and 8 describe three experiments which examine the activation and use of lexical information in nonword spelling.

In Chapter 6, it is proposed that morphemes, stored in the lexicon, may be used in nonword spelling. In order for this to occur, individual morphemes must be activated by phonemes contained within the nonword stimulus. This chapter describes a phoneme-classification task conducted with adults, in which it is shown that a morpheme can be activated by a phoneme when the phoneme is generated in a context in which that morpheme is primed.

In Chapter 7, an experiment is described in which adults spell nonwords which end in various pronunciations of a morpheme. In this experiment, the nonwords are presented in a primed condition, and two unprimed control conditions. It is shown that morphemes can be used in the spelling of the nonwords, and when presented in a primed condition, a morpheme is more likely to be used.

A subsequent experiment, described in Chapter 8, shows how morphemes can also be used by children in their spelling of nonwords, with the use of a morpheme again increasing when the nonword is presented in a priming context. However, an additional effect on the use of a morpheme is also examined: the amount of non-morphemic competition from alternative graphemes. It is found that non-morphemic frequency does not explain the differential use of a morpheme for different nonword endings. However, another measure was shown to determine the selection of a morpheme. This is the 'plausibility' of a nonword 'stem' which would have to be added to the morpheme, if that morpheme was used.

Chapter 9 provides an overview of the three studies and the three experiments, highlighting the findings of each. These findings are discussed in relation to the implications of this research for the teaching and testing of spelling. A number of limitations of this research are described and further research into the influence of lexical information on nonword spelling is suggested.

CHAPTER 2

Related research

2.1 Introduction

This chapter explains the functioning of the dual-route model of spelling and gives a flavour of the methodology used in research into children's spelling difficulties. It shows how this methodology has been based on the assumption that there is a direct link between kinds of spelling errors and underlying processing based on the dual-route model of spelling. It is shown that of the two types of spelling errors, phonetic and non-phonetic, phonetic spelling errors can be explained in terms of the dual-route model, but non-phonetic errors can not.

2.2 The dual-route model of spelling

Research into the cognitive processes underlying spelling has generally been carried out within the framework of a dual-route model (Nelson, 1980; Beauvois and Derouesne, 1981; Ellis, 1982; Hatfield and Patterson, 1983; Snowling, 1987; Barry, 1988; Barry and Seymour, 1988). This model takes the form of two independent routes by which words and nonwords are spelt. The research does not usually refer to this model explicitly. However, based on 'a "dual-route" model' described by Ellis (1982), the model described here will be referred to as 'the' dual-route model.

The two routes of this model are the 'lexical route' and the 'non-lexical route' (Figure 2-1). Researchers have used various other names to describe these routes, although the underlying functional principles remain the same.

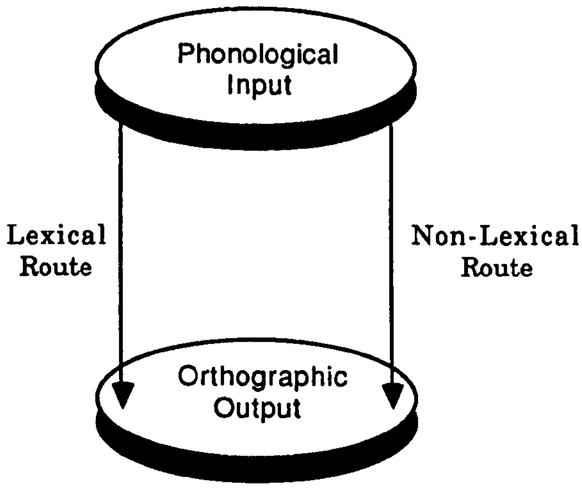

FIGURE 2-1. The dual-route model of spelling

2.2.1 The lexical route

Other names for the lexical route are the 'lexical phonological pathway' (Margolin, 1984), 'word-specific spelling' (Hatfield and Patterson, 1983) and the 'visuo-orthographic route' (Pain, 1985). The central feature of this route is that an orthographic representation (sequence of letters) for a whole word is stored in a functional location called the 'lexicon'. Spelling a word by this route involves accessing and retrieving the orthographic representation, and outputting the letters contained in that representation in the correct sequence (Figure 2-2).

We do not know the exact structure of information within the lexicon. However, it has been suggested by Morton (1980) that for the purposes of spelling, the '[grapheme output logogen system] contains spelling patterns for words (or possibly morphemes)' (p. 132). Thus we may think of items in the lexicon as being word stems such as 'head' and 'think', and affixes, such as 'ing' and 'ed'.

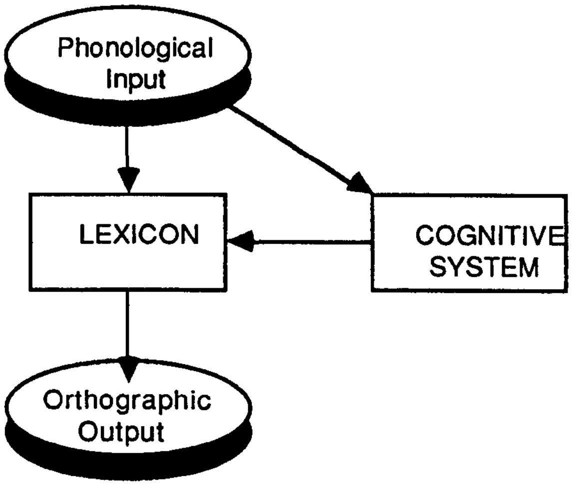

FIGURE 2-2. The lexical route

As well as being accessed directly by phonetic input, an orthographic representation can also be accessed indirectly via the cognitive system. The cognitive system (Morton, 1980) contains the semantic information which can be used to decide which representation is to be selected in the case of ambiguous phonological input. Thus, when a homophone such as 'two' is being accessed, the semantic information that the input /tuː/ refers to 'a number' causes us to access the correct orthographic representation 'two', rather than the phonologically identical 'to' or 'too'.

The lexical route can only be used to spell words for which there is a known orthographic representation which has been learnt, probably as a consequence of reading. Thus pronounceable strings of phonemes or 'nonwords', such as /fiːp/ (rhymes with 'deep'), cannot be spelt by this route. The lexical route must be used for spelling words which do not have a strictly phonetic structure, e.g. 'yacht', since spelling these words via the non-lexical route would result in incorrect spellings (e.g. 'yacht' spelt 'yot').

2.2.2 The non-lexical route

The non-lexical route (Ellis, 1982; Margolin, 1984; Barry and Seymour, 1988) has also been referred to as the 'phonological route' (e.g. Hatfield and Patterson, 1983; Pain, 1985). This route involves two consecutive processes: the segmentation of a word into smaller phonemic units, and the conversion of these phonemic units into graphemic units (Figure 2-3).

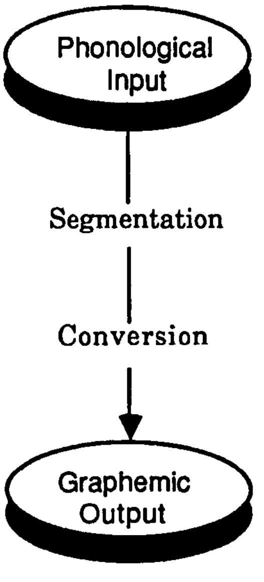

FIGURE 2-3. The non-lexical route

Here, the output is referred to as 'graphemic' rather than 'orthographic' (as in Figures 2-2 and 2-1) since it has been constructed from graphemes rather than from a knowledge of orthography, although the end result in each figure is the same, that is, a string of letters which are supposed to represent a string of phonemes. In the first stage of processing in the non-lexical route, the input is segmented into its constituent phonemes. Thus, for example, the word 'think' would be segmented into its four constituent phonemes, /θ/, /i/, /ŋ/ and /k/ (Figure 2-4). Most research considers the segmented units to be individual phonemes (e.g. Morton, 1980; Barry and Seymour, 1988) although others have suggested larger units may be involved (see Section 2.2.4.1). As the input to the non-lexical process is treated simply as a string of phonemes, it is theoretically possible for any string of phonemes to be processed non-lexically. Thus nonwords may also be segmented in this way, since they are essentially pronounceable strings of phonemes. For example, the nonword /snuː/ (rhymes with 'blue') would be segmented into the phonemes /s/, /n/ and /uː/.

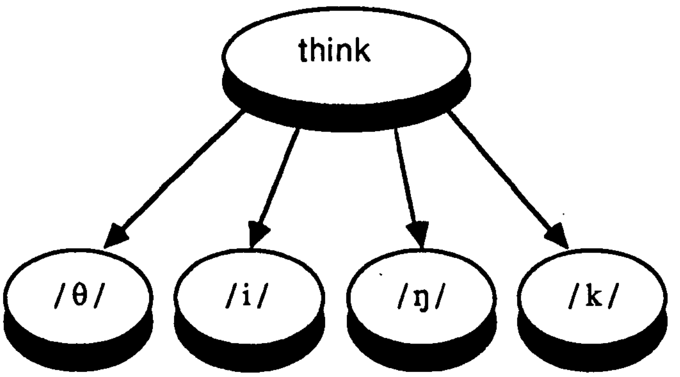

FIGURE 2-4. Segmentation in non-lexical processing

Once input to the non-lexical route has been segmented, each phoneme is converted into a grapheme, where a grapheme is the written representation of a phoneme (Coltheart, 1978). This conversion process is the second stage of non-lexical processing. Phonemes are mapped onto graphemes using 'phoneme-grapheme correspondence rules' (Hatfield and Patterson, 1983). Some phonemes, usually vowels, can be spelt with more than one grapheme in English. For example, the vowel phoneme /uː/ is spelt with a different grapheme in each of the following words: 'shoe', 'shrew', 'too', 'blue', 'through' and 'do'. Where there are several phoneme-grapheme mappings in English for a particular phoneme, it is thought that the grapheme which occurs in the most words is most likely to be selected (Barry and Seymour, 1988). This grapheme is referred to as the spelling pattern with the highest 'contingency' (Barry and Seymour, 1988). Once the phonemes have been converted to graphemes, the graphemes are concatenated and output to produce a complete spelling of the whole word or nonword (Figure 2-5).

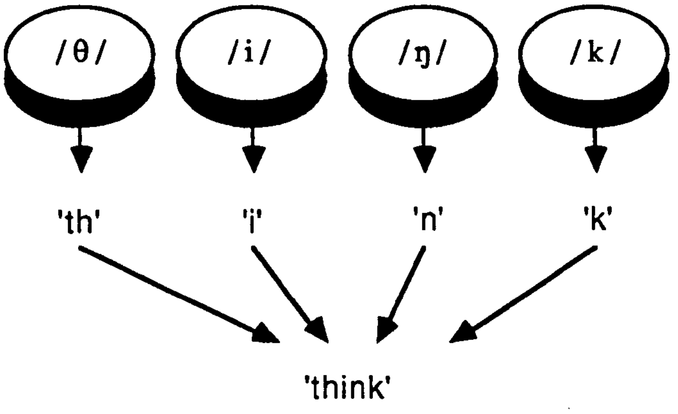

FIGURE 2-5. Phoneme-grapheme conversion and output

Graphemes are not always output in the same order as the original phonemes, since some of the graphemes have two parts which surround another. This is the case for vowel graphemes such as 'a_e' as in 'made', 'o_e' as in 'hole' and 'u_e' as in 'June', where the grapheme of the terminal consonant is written between the two letters of the vowel grapheme, rather than after it. The concatenation process allows for this to happen.

Because the non-lexical route operates at the level of phonemes, nonwords can be successfully written by this route to produce a spelling which, when read back by common spelling-to-sound correspondences, will sound like the original phoneme string of the nonword. Real words may be accurately spelt via this route if they have a regular spelling, i.e.

if they are spelt with high contingency graphemes. Thus the word 'feel' is likely to be spelt accurately via the non-lexical route. However, irregular words such as 'kneel' are unlikely to be spelt accurately via this route since they contain graphemes which are of low contingency (i.e. /n/ represented by 'kn').

2.2.3 Evidence for the dual-route model

Most evidence for the lexical and non-lexical routes in spelling comes from studies of patients with 'acquired dysgraphia'. These are adults who have suffered brain damage, one result of which is the impairment of writing skills. Research into the spelling of different types of word has shown impairments in one route resulting in an overreliance on the other route. Some studies have demonstrated a reliance on a lexical route in spelling by patients in whom a non-lexical route is impaired (e.g. Hier and Mohr, 1977; Shallice, 1981; Bub and Kertesz, 1982). In these studies it is shown that real words can be spelt correctly but nonwords cannot be spelt correctly. For nonwords, which have no known spelling, a 'correct' spelling counts as one which reads back as the original phoneme string, when the spelling is read according to common spelling to sound rules. For example, /fi:p/ spelt 'feep' or 'feap' would count as correct, but 'fep' or 'firp' would not.

Other studies have demonstrated an impaired lexical route and a consequent reliance on non-lexical processing (e.g. Beauvois and Derouesne, 1981; Hatfield and Patterson, 1983; Goodman-Schulman and Caramazza, 1987). In these studies, nonwords and regular words can be spelt accurately, but irregular words cannot be spelt correctly although the spelling may be phonetically accurate. It is inferred that the patient is relying on phoneme-grapheme conversion which produces accurate spellings for words which have a phonetic orthography, but which produces incorrect spellings for irregular words which must in general be spelt via the lexical route.

2.2.4 Unresolved issues

Although we have evidence for a dual-route model of processing in spelling, there remain unresolved issues within this area. One is concerned with the size of units which are converted from sound segments to graphemes in the non-lexical route, and another is the influence of lexical information on non-lexical spelling.

2.2.4.1 The units of non-lexical conversion

Some research has suggested that non-lexical spelling involves segmenting phonological input into units which are larger than a single phoneme. Baxter and Warrington (1987) examined a brain-damaged patient who could use the non-lexical route to spell regular words and nonwords. However they found that in real words some ambiguous vowel phonemes were spelt according to the context of the phoneme. For example, the vowel sound /ɜː/ is represented by different graphemes in each of the following words: 'bird', 'jerk', 'work', 'learn' and 'spurt'. The highest contingency spelling of this phoneme is 'ur' as in 'spurt' (Barry and Seymour, 1988). However, when the phoneme is preceded by the phoneme /w/ it is most commonly spelt 'or' as in the words 'world', 'worm' and 'word'. This grapheme is a low contingency spelling for the phoneme /ɜː/ generally, but it is a high contingency spelling when it occurs in this context. The patient in Baxter and Warrington's study appeared to be sensitive to the context of this ambiguous phoneme by using the lower contingency spelling 'or' when writing nonwords when the phoneme was preceded by the phoneme /w/. It was concluded that the unit of conversion in this patient's non-lexical spelling was therefore greater than a single phoneme. However, from this study it can not be ruled out that single phoneme-grapheme mappings are stored non-lexically, and that they are selected with respect to the phonemic context in which the target phoneme occurs. Although the issue of representation is important, it is not investigated within this thesis.

Baxter and Warrington's conclusion, that units greater than a single phoneme are segmented and mapped onto graphemic clusters, is similar to research into nonword reading where, following descriptions of a dual-route model also based on lexical and non-lexical processing, it was suggested that units greater than single graphemes were used to read nonwords (e.g. Marcel,1980; Shallice, Warrington and McCarthy, 1983). Sub-word units can be derived at a variety of levels. Shallice et al. (1983) describe a semantic dyslexic patient whose reading was reliant on this route (also called the 'phonological route'). They found that words were segmented into graphemes which were mapped onto the phoneme of highest frequency. For example, the grapheme 'ea' would be mapped onto the phoneme /iː/ as in 'gleam'. However, the segmentation of the grapheme was sensitive to context. This meant that in different contexts, the grapheme was sometimes pronounced different ways. For example, where the grapheme 'ea' was followed by 'd' in the letter string 'ead', the vowel was pronounced /e/ (as in 'head') rather than /iː/ (as in 'beak'). This was thought to have been because in real words, this grapheme is often pronounced /e/ when followed by 'd', as in the words 'head', 'lead', 'bread' and 'dead'. Such context sensitivity was taken as evidence that the phonological route may operate on visual word segments that can be larger than the individual grapheme, as was previously supposed (Coltheart, 1978), and that there are in fact a number of 'types of orthographic unit' upon which this segmentation can be carried out. These include 'graphemes, consonant clusters, sub-syllabic units, syllables and morphemes' (Shallice et al, 1983). It is therefore possible that such larger units may also be used in non-lexical spelling.

Ellis (1982) prefers to 'remain agnostic over the issue of whether [the non-lexical route] exploits individual sound-to-letter mappings...or whether it exploits larger multiletter conversion procedures' (p. 118). Goswami and Bryant (1990) believe that a word is segmented into two parts: an initial consonant cluster ('onset') and the rest of the word ('rime'). For example, 'bake' would be segmented into the phoneme /b/ and the phoneme string /eik/. The rime may be spelt by analogy to another word which rhymes with it, e.g. 'make' (Goswami, 1988). A problem with testing for spelling by analogy is that if the analogous word has a common sound-to-spelling pattern, as does the word 'make', the target word may simply have been spelt using this pattern and not by direct analogy to another single word.

For the purpose of this thesis, it is generally assumed that the unit of segmentation and conversion in non-lexical spelling is a single phoneme, which is converted to a single grapheme.

2.2.4.2 Lexical influences on nonword spelling

As well as the issue of the units of conversion, there continues to be debate about the use of real words in nonword spelling. Ellis (1982) maintains that an essential feature of the spelling process is that the lexical and non-lexical routes should be 'separable and dissociable' (p. 118). However, some studies have suggested that these routes may be interactive (e.g. Campbell, 1983; Campbell, 1985; Barry and Seymour, 1988). Campbell (1983; 1985) found that the spelling of a real word could influence the selection of a grapheme when writing a nonword. For example, when the word 'train' was heard prior to writing the rhyming nonword /prein/, the vowel phoneme in the nonword was more likely to be spelt 'ai' (as in 'train'). On the other hand, if the word 'crane' was heard prior to writing the same nonword, the grapheme selected for the vowel phoneme was more likely to be 'a_e'. This effect was called 'lexical priming'. It was concluded that hearing a word immediately before a nonword primed the phoneme-grapheme mappings that were contained within the real word. Thus, when selecting a phoneme-grapheme mapping for the nonword, the mapping which was primed was more likely to be selected. This lexical priming effect was also demonstrated by Barry and Seymour (1988).

A recent study by Seymour and Dargie (in press) has shown an indirect influence of lexical information on nonword spelling. They found that they could prime the grapheme used in a nonword with a real word which would activate a semantically related word. This semantically related word would then have a lexical priming effect. For example, when the nonword /boup/ was preceded by hearing the word 'vatican', the nonword was more likely to be spelt 'bope'. This is thought to be the result of the word 'vatican' being associated with the word 'pope', and this word in turn priming the vowel grapheme 'o_e' for use in the nonword spelling 'bope'. On the other hand, when preceded by hearing the real word 'detergent', the nonword was more likely to be spelt 'boap'. This was attributed to the association between the words 'detergent' and 'soap', the latter priming the grapheme 'oa' for use in the nonword. This was called an 'associative priming' effect.

Although nonwords were originally thought to be spelt using only the non-lexical route, the effects of lexical priming and of associative priming suggest that lexical information can influence nonword spelling. However, the resulting spellings of nonwords still use high contingency graphemes, resulting in phonetic spellings of the nonwords. There is no research to suggest that lexical information may be used to produce non-phonetic spellings.

2.3 Methodology in research into spelling difficulties

Literacy involves learning to manipulate representations of our language in two main ways: reading and writing. An essential component of writing is the selection of letters, or spelling, although the objective importance of correct spelling is open to debate. Much more research has been carried out in the area of reading than spelling. Research into spelling, largely carried out within the last two decades, is only now beginning to address issues of processing and impairment at the level of detail with which corresponding processes in reading have been investigated during the last 100 years (Venezky, 1980). One of the reasons for the delay in spelling research could be that spelling skills were thought to be picked up automatically during the course of learning to read, and so were not taught explicitly. Problems with spelling would be attributed to problems in reading, and once these have been resolved the former should go away.

Theoretical arguments against this approach have been put forward by Chomsky (1971), Schonell and Wise (1985) and Read (1986) who regard spelling as involving separate processes from reading. Evidence for the separation of reading and spelling difficulties comes from brain-damaged adults who suffer impaired writing without an equivalent impairment in reading (Beauvois and Derouesne, 1981), children who spell better than they read (de Grompone, 1974; Bryant and Bradley, 1980) and children who are poor spellers despite being good readers (Frith, 1980). A more visible argument is the fact that for most people spelling is harder than reading.

Another reason for the relative advancement of reading research is that there is an established methodology for testing hypotheses about reading processes, whereas there is no equivalent methodology in spelling research. Research into reading has made extensive use of 'reaction time' which is the length of time it takes for a subject to read a word. It is measured by flashing a word up on a screen, and measuring the amount of time that elapses before the subject begins to say the word - this point is referred to as 'voice onset'. When a subject is under pressure to say the word as quickly as possible in an experimental situation, this method yields reliable measures which can be compared for different types of words, e.g. real words versus nonwords (e.g. Glushko, 1979) and regular words versus irregular words (e.g. Bub, Cancelliere and Kertesz, 1985). This methodology is based largely on the assumption that the more processes are involved in decoding a word, the longer it will take to read.

There is no comparable methodology used in spelling research. One reason is that reading a word may be a fast, almost automatic process which does not require much deliberate thought. On the other hand, the writing of a word can begin before the person is fully confident of the letters he or she should be writing. The spelling is sometimes 'worked out' as they go along. Sometimes a person will pause in the middle of writing a word while they 'work out' what letter to write next. Children, if they are not sure of a word's spelling, will sometimes add letters to the end in the hope of making it look better (Sibbitt, 1989a). Thus where reading latencies reflect the amount of time it takes to either activate an orthographic representation or to construct a pronunciation, the act of writing is a lot more deliberate.

The most established methodology in spelling research is the coding of spelling errors as 'phonetic' or 'non-phonetic'. From the predominant kind of error made, an inference is made about the underlying processes used by a child, and more specifically, an inference is made about the deficits in a child's processing. Deficits are interpreted in terms of the dual-route model of spelling already described.

The procedure of classifying spelling errors is 'fraught with difficulty' (Snowling, 1987). A main problem with this methodology is that it is difficult to know exactly what researchers mean by 'phonetic' and 'non-phonetic' (Sibbitt, 1988; 1989b). Definitions of these terms are not readily given; it is usually assumed to be an intuitively obvious categorization. Goulandris (1990) for example, categorizes errors on nonword spellings as 'phonetic', 'semi-phonetic' and 'non-phonetic'. Phonetic errors are defined as 'anything which sounds vaguely right', e.g. the nonword /ind/ (rhymes with 'grinned') spelt 'ind' or 'ined'. Semi-phonetic errors consist of spellings where the consonant framework is maintained, e.g. /saik/ (rhymes with 'bike') spelt 'sik', or /meif/ (rhymes with 'waif') spelt 'maf'. Non-phonetic errors are those which 'didn't sound at all like the intended word', e.g. /gitəl/ (rhymes with 'little') spelt 'kall', or /ind/ spelt 'end'. These definitions of what is phonetic and what is non-phonetic are questionable, since, for example, 'end' may be considered to be a phonetic spelling of /ind/ if the speaker of the nonword has a South African accent.

A study by Boder (1973) also categorised children's spelling errors on real words as either phonetic or non-phonetic. Again, no explicit definitions of these categories were given. However, children who made mostly 'non-phonetic' errors were assumed to have impaired lexical and non-lexical routes as described below:

> "[He] attempts to spell by sight alone, and not 'by ear', for he has difficulty in learning what the letters sound like...He spells correctly to dictation only those words in his sight vocabulary, phonetic or not, that he can revisualize. Typically, the correctly written words are islands in a sea of dysphonetic mis-spelling, in which the original words can seldom be identified even by himself - although some idea of phonetics may be evident (e.g. 'sleber' for 'scrambled'...). In his spelling list of known words selected from his sight vocabulary a non-phonetic word may be written correctly, whereas in the list of unknown words (not in his sight vocabulary) a phonetic word as simple as 'stop' or 'did' may be bizarrely mis-spelled...Extraneous letter errors and omitted-syllable errors are characteristic...he is unable to analyze the auditory gestalt of a spoken word into its component sounds and syllables; he is unable to syllabicate." (p. 669)

Some of the spellings categorised by Boder as non-phonetic are shown in Table 2-1. Based on errors such as these, a child who makes phonetic spelling errors is characterised as follows:

> "He spells...'by ear'. His mis-spellings are therefore 'phonetic', and the original word can usually be readily identified in his spelling list, by himself and others (e.g. 'laf' for 'laugh', 'burd' for 'bird', 'tok' for 'talk', 'hows' for 'house', 'lisn' for

'listen', 'bisnis' for 'business', 'onkl' for 'uncle', 'vakashn' for 'vacation')." (p. 670)

Thus phonetic errors are explained in terms of spelling by the non-lexical route ('by ear') but non-phonetic errors can only be attributed to impairment in both spelling 'by ear' and 'by sight'.

Intended word	Child's spelling
rough	refet
characters	coetere
scholar	sker
doubt	diter
inventor	interver
marmalade	mar
scrambled	sleber

TABLE 2-1. Non-phonetic spelling errors (from Boder, 1973)

A study by Temple (1986) examined the spelling errors of two children with spelling difficulties and categorised them as 'phonologically plausible' or as 'phoneme-grapheme errors', based on the classification scheme used by Hatfield and Patterson (1983) in their analysis of an adult with acquired agraphia. 'Phonologically plausible' errors are defined as those which, 'if read aloud, they would be homophonic with the target' (p. 84). Examples of these are 'clue' spelt 'cloo', 'fight' spelt 'fite' and 'relation' spelt 'rulashion'. 'Phoneme-grapheme errors' are those where the spelling includes a 'missing or extra final *e*', e.g. 'these' spelt 'thes' and 'sunshine' spelt 'sunshin', or a 'hard/soft *g*', e.g. 'large' spelt 'larg' and 'strange' spelt 'strang'. The child who makes mostly 'phonologically plausible errors' is thought to be relying upon the phonological (i.e. non-lexical) route in spelling. The child who makes hardly any phonologically plausible errors is thought to have an impaired phonological route, relying on an impaired 'lexical-semantic' route.

It can be seen that there is no specific definition of what constitutes a phonetically accurate or inaccurate error. However, whichever definition is used, the implications within most spelling research are the same: spelling errors which are considered phonetically accurate are evidence of use of the non-lexical route, in the absence of a fully functional lexical route; spelling errors which are phonetically inaccurate are evidence of both an impaired lexical route and an impaired non-lexical route. Thus, phonetic errors are explained in terms of phoneme-grapheme mapping where, because of the variety of ways in which a phoneme may be spelt, the wrong grapheme is chosen. There is no equivalent explanation of non-phonetic errors; these can not be explained in terms of the dual-route model.

Within this thesis, the definition of a phonetic spelling, where this is relevant to the study, is made clear in each chapter. In Chapters 3, 4 and 5, a non-phonetic spelling of a nonword is considered to be one for which a phoneme has not been spelt using one of the two most common spellings of that phoneme in English. In Chapter 6, a phonetic spelling of a phoneme is considered to be the letter name which sounds like the phoneme. In Chapters 7 and 8, a phonetic spelling of a nonword ending is considered to be the most common spelling of that phoneme cluster when it occurs at the end of real words.

2.4 Conclusions

This chapter has described the dual-route model of spelling and research into children's spelling difficulties which has been carried out within this framework. It has been shown that while phonetic spelling errors are explained in terms of non-lexical processing, no functional explanation is given for non-phonetic spelling errors.

In Chapter 1 it was proposed that children with spelling difficulties have non-phonetic graphemes in their phoneme-grapheme correspondence rules, or phoneme-grapheme 'grammar'. In the next chapter, a pilot study is described which investigates the phoneme-grapheme mappings of children with spelling difficulties.

CHAPTER 3

How children with spelling difficulties spell nonwords: A pilot study

3.1 Introduction

The previous chapter described the dual-route model of spelling. A limitation of the dual-route model is its inability to explain why children construct non-phonetic spellings of real words and nonwords. These are spellings which, when read back using common spelling-to-sound mappings, do not sound like the intended word or nonword, e.g. 'make' spelt 'mek'. We do not yet have a detailed model of how children spell nonwords. However, recent research (Barry and Seymour, 1988) has been carried out into how adults spell nonwords. In the previous chapter it was described how a nonword first has to be segmented into its constituent phonemes, e.g. /dæt/ is segmented into the phonemes /d/, /æ/ and /t/. Each phoneme is then mapped onto a grapheme, e.g. /d/ onto 'd', /æ/ onto 'a' and /t/ onto 't'. However, most vowel phonemes have a range of possible spellings in English, and only one of these needs to be selected when spelling the nonword. Barry and Seymour showed that this selection was carried out on the basis of 'contingency'.

'Contingency' refers to the type frequency with which a grapheme is used to represent a phoneme in English words, i.e. the number of words in which a phoneme is spelt a particular way. Barry and Seymour computed the number of ways individual vowel phonemes were spelt in English words. They took monosyllabic words (e.g. 'feet') and disyllabic words where the second syllable was unstressed (e.g. 'mason') looking at the first vowel phoneme. For each vowel phoneme they ascertained the graphemes which were used to spell it, and computed the number of words which contained that grapheme. In this way they were able to establish how often phoneme-grapheme mappings occurred in English words. The mappings which occur most often for each phoneme are referred to as being of 'high contingency'. This is a relative term, meaning that it is the most commonly used grapheme for that phoneme. In their experiment they were able to show that in selecting a spelling for a vowel phoneme, adults tended to use the highest contingency phoneme-grapheme mapping.

It was suggested in their study that the phoneme-grapheme mappings stored by an adult have information associated with them which denotes their sound-to-spelling contingency. Using this information an adult can access the highest contingency phoneme-grapheme mappings when spelling nonwords. The mappings that they have stored, and the relative frequencies associated with them, are the frequencies of the phoneme-grapheme mappings as they occur in English.

However, it is possible that the adults in Barry and Seymour's study did not actually have a full set of English phoneme-grapheme mappings, but instead had a set of mappings which were derived directly from the words in their sight vocabulary. If the adults were highly literate, the frequencies of the phoneme-grapheme mappings derived from their sight vocabulary would be approximately the same as the frequencies of phoneme-grapheme mappings in English. Thus, their ability to access the highest contingency mappings for spelling nonwords may be due largely to them having a large sight vocabulary containing a representative subset of the phoneme-grapheme mappings found in all English words. It may therefore be more plausible to suppose that adults are aware of an approximation to English mappings and their frequencies, rather than to actual linguistic mappings and their frequencies.

In this thesis it is proposed that children's phoneme-grapheme mappings may differ from those of adults. This is because the child's lexicon contains a different set of words to the adult, and it is from this set of words that the set of phoneme-grapheme mappings is derived. A child's lexicon may differ from that of an adult in two ways. Firstly, it may contain less words than that of an adult. This is because in the course of learning to read, a child will have only encountered a subset of the words which an adult will know. Secondly, a child's lexicon may contain incorrect spellings. This is because the child may have seen a word and encoded it wrongly. In the course of seeing it more often, this inaccurate representation may be corrected. However, at any one time, incorrect representations of real words may be stored in the lexicon.

Despite having a limited sight vocabulary, and possibly having a sight vocabulary which contains incorrect spellings, it is still possible for a phoneme-grapheme grammar to be derived from these spellings. However, a phoneme-grapheme grammar derived from these spellings may differ considerably from phoneme-grapheme mappings and their frequencies which are found in English. Those mappings which are high contingency for a child may be low contingency in English, or may even be non-existent.

For this reason, it is proposed that 'high contingency' mappings should refer to those mappings which are of highest contingency for a particular individual. Thus, high contingency mappings for an adult will reflect the most commonly occurring mappings in English, but may be different for a child. Furthermore, the high contingency mappings of one child may be different to those of another child. In this thesis, the term 'contingency' is therefore used to refer to the frequency associated with a phoneme-grapheme mapping in an individual's phoneme-grapheme grammar.

The pilot study reported in this chapter aims to show that although children's spellings of vowel phonemes may be non-phonetic when compared to English phoneme-grapheme mappings, they make sense in terms of the phoneme-grapheme grammar which the child possesses. The graphemes selected by a child are therefore high contingency mappings in terms of their own phoneme-grapheme grammar. This is demonstrated by comparing the vowel grapheme used in a nonword to the vowel graphemes used to spell real words containing the same vowel phoneme. It was thought that if a child spells the words he or she knows, these will be spellings that are contained in the lexicon. From these spellings, a phoneme-grapheme mapping system will have been derived. For a particular vowel phoneme, the most common grapheme representing it in words in the lexicon will be reflected as the highest contingency phoneme-grapheme mapping in the mapping system. When a child hears a nonword, and then spells all the real words he or she knows which rhyme with the nonword, the spelling of a vowel phoneme used most often in the real words may be considered the highest contingency grapheme in the phoneme-grapheme mapping system. It is this grapheme which should then be used to spell the vowel phoneme in the nonword. This is the first prediction listed in Section 3.1.1.

In the study, children are asked to spell a range of nonwords containing different vowel phonemes, and to spell all the real words they can think of which rhyme with the nonword, i.e. those which contain the same vowel phoneme and terminal consonant phoneme (e.g. /haud/ rhymes with 'loud'). In some cases, the child is asked to spell the nonword before writing down the real words. In other cases the child is asked to write the nonword after writing down the real words. In some cases the child is asked to write the nonword twice: once before writing down the real words, and once after writing the real words. These differences in procedure are described in more detail below (see section 3.2.4.3).

So far it has been assumed that in this study, real words will be spelt lexically and nonwords will be spelt non-lexically using high contingency phoneme-grapheme mappings. However, the Barry and Seymour experiment also showed that the spelling of a nonword was subject to 'lexical priming'. This means that when a real word is presented before a nonword containing the same vowel phoneme, e.g. 'meek' presented before the rhyming nonword /fi:k/, the grapheme used in the real word is likely to be used in the nonword. Hence, in this example, /fi:k/ is likely to be spelt 'feek'. On the other hand, if this nonword was preceded by the real word 'beak', the nonword is more likely to be spelt 'feak'. The effect of the preceding real word on the spelling of a nonword is called 'lexical priming'.

It is possible that lexical priming may occur in the present study, since this study involves the writing of nonwords and real words containing the same vowel phoneme. Where the real words are written before writing the nonword, it is possible that the last real word will have a priming effect on the spelling of the nonword. In this study, if the last real word, or 'priming word', is not spelt with the most frequently used grapheme in all of the real words, the nonword may be primed with a grapheme which is different to the most frequently used grapheme. This would contradict the first prediction, i.e. that the nonword should have the same grapheme as the most frequently used grapheme in the real words. However, where a nonword does not have the most frequently used grapheme, the discrepancy may be explained in terms of lexical priming if its grapheme is the same as that used in the preceding real word. This is listed as the second prediction.

It has already been stated that a nonword is thought to be spelt using the highest contingency phoneme-grapheme mapping. In some cases in this study, the same nonword is spelt twice: once before writing the rhyming words and once after writing the rhyming words. Where a nonword is spelt twice, we may expect that the second spelling uses the same grapheme as the first , since the highest contingency phoneme-grapheme mapping should be used in each case. Thus it is predicted that a child will be consistent in their selection of the high contingency grapheme. This is listed as the third prediction.

The second spelling of a nonword follows the spellings of the real words and may therefore be subject to a priming effect. Thus, where the second nonword is spelt differently to the first, it is predicted that the grapheme contained in the second nonword will be the same as that in the preceding real word. This is listed as the fourth prediction.

3.1.1 Summary of predictions

The following results are expected:

(1) the most frequently used grapheme in the real words is also used in the nonword;

(2) nonwords which do not have the most frequently used grapheme have the grapheme of the preceding real word instead;

(3) nonwords which are spelt twice contain the same grapheme in both cases; and

(4) where a second nonword contains a different vowel grapheme from the first, its grapheme will be the same as that in the preceding real word.

3.2 Method

3.2.1 Design

A single group of children was used. All the children spelt the same set of nonwords, presented before, after, or both before and after writing all the rhyming words they could think of.

3.2.2 Subjects

Eleven children with spelling difficulties were selected for the study. There were 9 boys and 2 girls who had been referred by their local education authority for extra reading and spelling tuition. The children had received extra tuition for a duration of between 6 months and 2 years

10 months. Six of the children had been attending a reading unit for 2 hours a week; the other five had been visited in their schools for 2 hours a week. On the day of the experiment, all the children were tested in the reading unit.

The mean chronological, reading and spelling ages for the whole group are shown in Table 3-1. Reading ages, calculated on the Neale Analysis of Reading Scale (Neale, 1958), were available for all but one child. Spelling ages, calculated on the SPAR spelling and reading test (Young, 1976) were available for all the children.

Chronological age (N=11)	Reading age (N=10)	Spelling age (N=11)
10.43 (0.99)	8.17 (0.86)	8.27 (0.90)

TABLE 3-1. Mean chronological, reading and spelling ages in years (standard deviations in brackets)

Spelling and reading difficulty (or 'retardation') can be measured by the difference between spelling or reading age and chronological age. The mean differences between spelling and reading ages and chronological age are shown in Table 3-2. Reading ages were an average of 2.17 years below chronological ages ($t=8.714$, $df=9$, $p_{1\text{-tail}}<0.001$) and spelling ages were an average of 2.15 years below chronological age ($t=10.551$, $df=10$, $p_{1\text{-tail}}<0.001$). In children with specific literacy difficulties, spelling is usually more impaired than reading. In this group, however, the difference between mean reading and spelling ages was not significant ($t=0.495$, $df=9$, n.s.) indicating that as a group, the children were equally impaired in both skills.

Reading retardation (N=10)	Spelling retardation (N=11)	RA - SA (N=10)
2.17 (0.79)	2.15 (0.68)	0.07 (0.45)

TABLE 3-2. Mean reading retardation, spelling retardation and difference between reading age (RA) and spelling age (SA) in years (standard deviations in brackets)

3.2.3 Materials

The materials consisted of 15 nonwords containing the 15 vowel phonemes used in Barry and Seymour's experiment. Five of these were 'consistent' vowels and 10 were 'inconsistent' vowels. This distinction is related to the percentage of spellings accounted for by the highest contingency spelling, where 'high contingency' here refers to the most commonly used grapheme in all English words. For some phonemes, the most commonly used grapheme is used in a higher proportion of words than for other phonemes. For example, the highest contingency grapheme for the phoneme /i:/ (as in 'speak') is 'ea'. This accounts for 40% of all occurrences of this phoneme. The highest contingency grapheme for the phoneme /i/ (as in 'pip') is 'i'. This grapheme occurs in 97% of all occurrences of this phoneme. Barry and Seymour defined vowel phonemes whose highest contingency grapheme accounted for less than 70% of all occurrences as 'inconsistent'. Vowel phonemes whose highest contingency grapheme accounted for more than 90% of all occurrences were classified as 'consistent'[1]. The 10 vowel phonemes classified as 'inconsistent' were as follows:

/iː/ /ɔː/ /uː/ /əː/ /ai/ /ou/ /ei/ /u/ /au/ /ɔi/

The five vowel phonemes classified as 'consistent' were as follows:

/i/ /e/ /æ/ /ɔ/ /ʌ/

A monosyllabic nonword was devised for each of the 15 vowel phonemes. The nonwords were all of a CVC (consonant-vowel-consonant) type. The vowel phonemes and their nonwords are shown in Table 3-3, alongside examples of rhyming words containing that vowel phoneme.

3.2.4 Procedure

Ten of the children were presented with all 15 nonwords. One child was presented with only five of the nonwords owing to lack of time. Each child was tested individually.

The child was told that they were going to hear some nonwords which weren't really words, but which sounded like they could be. After the experimenter said a nonword, the child had to repeat it to ensure that it had been heard properly. When the experimenter was sure that the vowel phoneme had been heard accurately, the child was asked to either

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[1] Note that Barry and Seymour's definition of 'consistency' is not the same as the notion of consistency defined earlier which refers to the selection of the same grapheme each time when spelling a nonword more than once.

write down the nonword immediately or write down all the real words which they could think of which rhymed with the nonword. The order in which the real words and the nonwords were written is described in more detail below.

CONSISTENT VOWELS			INCONSISTENT VOWELS		
Phoneme	Nonword	Real word	Phoneme	Nonword	Real word
/i/	/vip/	lip	/i:/	/fi:k/	leak
/e/	/ked/	red	/ɔ:/	/sɔ:k/	pork
/æ/	/fæp/	lap	/u:/	/pu:t/	moon
/ɔ/	/rɔp/	top	/ə:/	/sə:k/	lurk
/ʌ/	/lʌn/	bun	/ai/	/pait/	white
			/ou/	/youp/	rope
			/ei/	/peit/	late
			/u/	/tul/	pull
			/au/	/haud/	loud
			/ɔi/	/mɔil/	soil

TABLE 3-3. The 15 vowel phonemes used in the study, the nonwords containing them and examples of real words containing the phonemes

When the child was asked to write the nonword, it was emphasised that since it wasn't a real word, there was no right or wrong way to spell it and that they should write the first spelling which comes to mind.

When writing the real words, they were asked to think of as many real words as possible which rhymed with the nonword and write them down, one below the other. Where the child appeared to have difficulty thinking of rhyming words, semantic clues were given by the experimenter. For instance, in thinking of words that rhymed with /ked/, a child might be asked, 'What do you call this thing on your shoulders?' When they replied with the right word, i.e. 'head', they wrote it down. An attempt was made by the experimenter to prompt the child to think of a wide range of words which contained all possible graphemes. Thus, to rhyme with the nonword /ked/, the child would be encouraged to think of words such as 'head' and 'bed'. At no time did the experimenter say a real word before the child had said it.

Three procedure variables were introduced during the course of the experiment. These were:

(i) the order in which the nonwords were presented,

(ii) the use of masking, and

(iii) the order in which the nonword and the real words were written.

Since they were not included in the original design of the experiment, there was not enough data in each condition to conduct statistical analysis with respect to these variables.

3.2.4.1 Presentation Order

At the beginning of the experiment, the 10 inconsistent vowel nonwords were given first, followed by the 5 consistent vowels. This was because the attention span of the children was expected to be short, and as it was expected that they would find the inconsistent vowels more difficult to find rhymes for (as they are rarer), they were given first.

However, after the second child had been tested it became apparent that despite finding it easier to think of rhyming words for the consistent vowels, the children sometimes found the whole concept of rhyming difficult. They found rhyming easier after they had done it a few times.

Because of this, it was decided to give the (easier) consistent vowels first as practice in rhyming. Success in generating rhyming words for these appeared to give the children more confidence for tackling the later, more difficult sounds. The presentation order was therefore changed to presenting the consistent vowel phonemes followed by the inconsistent vowel phonemes. The first two children tested were presented with the inconsistent vowels first; the rest of the children were presented with the consistent vowels first.

Within each group of vowel phonemes, the presentation order remained the same. The consistent vowel phonemes were presented in the following order: /i/, /e/, /æ/, /ɔ/, /ʌ/. The inconsistent vowel phonemes were presented in the following order: /iː/, /ɔː/, /uː/, /əː/, /ai/, /ou/, /ei/, /u/, /au/, /ɔi/.

3.2.4.2 Masking

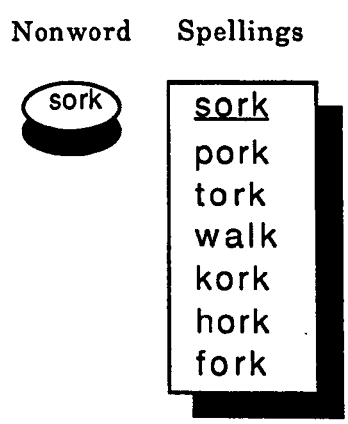
Masking was introduced during the study when it was noticed that, in writing the real words, some children appeared to be copying the vowel graphemes of the preceding words without thinking about them. From the sixth subject onwards, each word that was written down was immediately covered with a piece of paper before the next rhyming word was thought of and written below it.

3.2.4.3 Writing Order

The writing order for each nonword was the order in which the nonword and the real words were written down. Three conditions of writing order were introduced as it was thought that writing a nonword may introduce a priming effect on the spelling of a nonword.

(i) Nonword - rhyming words

In this condition, the nonword was written down immediately after it had been heard correctly by the child. The nonword spelling was underlined by the child and the real words were immediately written down afterwards. The nonword was underlined to separate it from the real words to enable later analysis. An example of the data produced under this condition is given in Figure 3-1.



3-1. This figure shows that the nonword stimulus was spoken first, the child spelt the nonword and underlined it, and then wrote down all the rhyming words they could think of

A total of 25 phonemes (i.e. 25 nonwords) were presented under this condition.

(ii) Rhyming words - nonword

In the second condition, the child was told the nonword and asked to say it without writing it, then asked to write all the rhyming words they could think of. Finally they were asked to write the nonword. An example of data collected under this presentation condition is given in Figure 3-2.

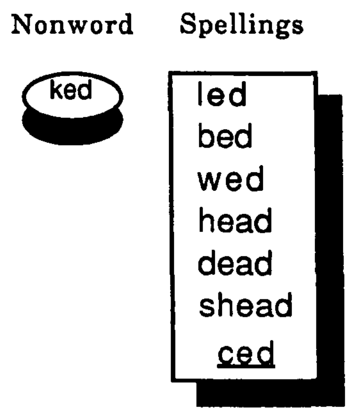


FIGURE 3-2. This figure shows that the nonword stimulus was spoken first, the child wrote down all the rhyming words they could think of, and finally wrote the nonword and underlined it

This writing order was introduced after it was thought that the spelling of the nonword, however it was spelt, could prime the spelling of the first real word. Obviously, if the nonword was primed by the most significant word, and the most significant word is the first real word, then the nonword and the first real word will be spelt similarly. However, if the nonword was spelt some other way and this primed the spelling of the first real word, the first real word could still be thought of as the most significant word but its spelling could not be taken as its lexical representation. In this condition, the spelling of the first real word *can* be taken as unprimed and therefore as its lexical representation. A total of 103 nonwords were presented under this condition.

(iii) Nonword - rhyming words - nonword

In the third condition, the nonword is written both before and after the rhyming words. This is a direct test for the effect of the intervening rhyming words on the spelling of the nonword. If both spellings of the nonword are identical it can be concluded that the actual writing of the rhyming words has no effect.

An example of the data collected under this presentation condition is given in Figure 3-3.

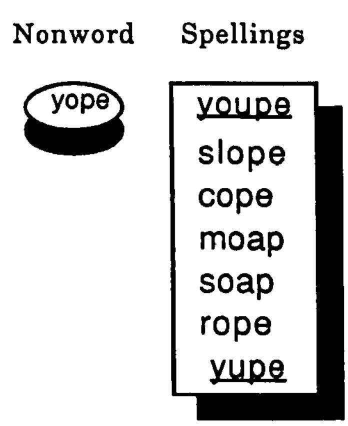


FIGURE 3-3. This figure shows that the nonword stimulus was spoken first, the child wrote it down and underlined it, then wrote all the rhyming words they could think of, and finally wrote the nonword again and underlined it

A total of 27 presentations of phonemes were made under the third condition.

3.3 Results

For each group of rhyming words written, the most frequently used vowel grapheme was ascertained. Where the most frequently used grapheme occurred as often as another grapheme, these graphemes were regarded equally as the most frequently used grapheme. A comparison was then made between the grapheme used to spell the nonwords, and the most frequently used grapheme occurring in the rhyming real words.

In all, a total of 177 nonwords were written by the 11 children. Of the vowel graphemes used in the nonwords, 142 were the same as the most frequently used grapheme in the rhyming real words (80.2%). This confirms the first prediction listed above, that the most frequently used grapheme used in the real words would also be used in the nonword. However, no statistical analysis could be carried out on this data because of the varying procedures used during the experiment.

This left 35 nonwords which were spelt with a grapheme which differed from the most frequently used grapheme in the rhyming real words. Of these, 21 were written immediately after writing a real word. However, only one of these contained the same grapheme as that in the preceding real word. Thus the second prediction, which was that priming by a real word would account for nonwords containing a grapheme different to the most frequently used grapheme, was not confirmed.

Twenty-seven of the nonword stimuli presented were spelt twice: once before writing the rhyming real words, and once after writing the rhyming real words. Out of the 27 pairs of nonword spellings, 22 pairs were spelt with the same vowel grapheme (81.5%). This confirmed the prediction of consistency in the spelling of nonwords.

This left 5 pairs of nonwords where the second spelling differed from the first. In only 2 of these pairs was the grapheme the same as that in the preceding real word. Thus the fourth prediction, that of a priming effect accounting for differences between two spellings of the same nonword, was not confirmed.

3.4 Discussion

This pilot study tested two main premises: the first was that phoneme-grapheme mappings were derived from words stored in the lexicon. The graphemes used in these words to represent a particular phoneme would be transmitted to a store of phoneme-grapheme mappings. These phoneme-grapheme mappings would have associated with them information about their relative frequency. The one which occurred most often in the lexicon would be the phoneme-grapheme mapping with 'highest contingency' in the non-lexical store.

The second premise was that the highest contingency phoneme-grapheme mapping would be used to spell nonwords. In Barry and Seymour's study, adults were found to use phoneme-grapheme mappings which were most frequent in the English language. However, it is suggested that adults do not have direct access to the frequency of phoneme-grapheme mappings in English; rather, they have a sight vocabulary which contains a subset of English words. This in turn yields a phoneme-grapheme grammar which approximates the frequencies of phoneme-grapheme mappings found in English. It is proposed here that this information is derived from the lexical store of words possessed by an individual.

It was not possible to work out whether all the nonwords following real words were subject to lexical priming. This is because for most of these nonwords the vowel grapheme in the nonword was the same as both the grapheme in the previous real word and the most frequently used grapheme. However, if a priming effect was responsible for the spelling of these nonwords, we should also be able to detect it in the nonwords whose graphemes were different from the most frequently used grapheme. A priming effect on these nonwords would mean that their graphemes were the same as those in the preceding real words. However, only 1 out of 21 nonwords had the same grapheme as the preceding real word. Hence it was concluded that the graphemes in the nonwords which followed real words could not be attributed to a priming effect, even though the graphemes were mostly identical. Although this result was contrary to expectations, it supports the proposal that nonwords are spelt using the highest contingency phoneme-grapheme mappings.

Where nonwords were spelt more than once, most of them were spelt using the same grapheme each time. This consistency can be interpreted in terms of the child selecting the highest contingency grapheme each time they spell the nonword. However, more presentations of the same vowel phoneme in different nonwords may provide stronger evidence of a child's consistency in nonword spelling. No priming effect was found to account for differences between two spellings of a nonword, which further supported the proposal that the nonwords were spelt using high contingency phoneme-grapheme mappings rather than by lexical priming.

From this study, it may be concluded that children spell nonwords using the highest contingency phoneme-grapheme mappings in their phoneme-grapheme mapping system. Furthermore, these phoneme-grapheme mappings are derived from the spellings contained in their sight vocabulary. This suggests that the adults in Barry and Seymour's experiment may also have used phoneme-grapheme mappings which were derived from words contained in their own sight vocabularies, this set of words being representative of the English vocabulary generally.

A methodological limitation of this study was that statistical analysis could not be carried out on the data. One reason for this was that the design was not explicitly comparative, so the data could not be compared to a control condition. In addition to this, the procedure was altered during the study in terms of the order of nonwords presented, the use of masking and the order of writing the real words and the nonwords.

However, a further question remains about the validity of the data collected in the study. This is based on the fact that the set of real words thought of and written by the child were assumed to be stored in the lexicon. It was thought that if a child knew a word, this meant that they would have a lexical representation for it. This, in fact, may not be the case, since, as in the case of preliterate children and illiterate adults, it is possible to know a word without knowing how it is spelt. Hence, being able to say a word does not mean we have a lexical representation for it. All we can safely infer from this is that a person has a semantic representation (in being able to access the word via its meaning) and a phonetic representation (in being able to access it via its phonetic similarity to other words). As a result it is possible that some of the real words were not written by accessing lexical representations. In fact, it is possible that they were spelt by using the highest contingency phoneme-grapheme mappings, in the same way in which the nonwords were spelt.

If this were the case what would be the implications of the results described above? If all the real words had been spelt non-lexically, we would expect all the vowel graphemes to be taken from the highest contingency phoneme-grapheme mapping. Thus we would expect them all to be spelt using the same grapheme. However, this was not the case: many real words were spelt correctly, using different graphemes to represent the same phoneme, e.g. 'dead' and 'bed'.

If a proportion of the real words had been spelt non-lexically, it would still have appeared that the most frequently used grapheme in the real words was the highest contingency phoneme-grapheme mapping in the phoneme-grapheme grammar, because a higher proportion of the real words were indeed spelt using this grapheme. However, we could not use the data to support the idea that the phoneme-grapheme grammar is derived from words in the lexicon, because we would not be able to distinguish between words that had been spelt lexically and words which had been spelt non-lexically. Thus in investigating non-lexical processing it is preferable to look in more detail at nonword spelling where we can be sure that the stimulus word has not been spelt lexically.

Because of this limitation, a second study was devised. The aim of this study was to examine more closely the phoneme-grapheme grammars of children with spelling difficulties by presenting the children with a number of nonwords containing the same vowel phoneme. An additional factor in this study was that the nonword spellings of the children with spelling difficulties were compared to those of children with 'normal' spelling ability. The aim of this was to see if the spelling difficulties of the first group could be attributed to characteristics of their phoneme-grapheme grammar.

3.5 Conclusions

This chapter has described a pilot study in which children with spelling difficulties wrote nonwords and real words containing the same vowel phonemes. The study showed that these children's phoneme-grapheme mappings were derived from the real word spellings stored in the lexicon. It also showed that the highest contingency phoneme-grapheme mapping would be the one selected when spelling a nonword. However, since it was not certain that the spellings of real words were accessed in the lexicon, it was proposed that the investigation of non-lexical processing be restricted to the examination of nonword spelling.

CHAPTER 4

A comparative study of vowel spelling in nonwords

4.1 Introduction

Results of the pilot study reported in Chapter 3 suggest that children with spelling difficulties use their own phoneme-grapheme grammars when spelling nonwords. These grammars are possibly derived from words stored in the child's lexicon. The most frequent spelling of a phoneme becomes the highest contingency phoneme-grapheme mapping for that phoneme, and is most likely to be selected when spelling a nonword.

One of the aims of that study was to show that children with spelling difficulties were consistent in their selection of the highest contingency phoneme-grapheme mapping. This was attempted by showing that where a nonword was spelt twice, the same grapheme was used in each case. However, stronger evidence for the use of this grapheme would be provided if it could be shown that in different nonwords, the same vowel grapheme was used each time.

In the study reported in this chapter, children with spelling difficulties are presented with sets of nonwords, each set containing the same vowel phoneme. It was expected that they would be consistent in the grapheme they used to spell each phoneme, since each time the highest contingency phoneme-grapheme mapping would be selected from their phoneme-grapheme mapping system.

The phoneme-grapheme mappings which each child uses, however, may not be the same as those found in English. This is because the child is still developing a sight vocabulary and may not have orthographic representations for a representative subset of English words. Furthermore, if the child is experiencing difficulties with reading they may have had problems encoding the orthographic images of words, and may as a result have incorrect spellings stored in their sight vocabulary. Thus, the phoneme-grapheme mappings which are derived from the lexicon may not only be of low contingency with respect to English phoneme-grapheme mappings, but may also be mappings which are not found in English at all.

We may use this to distinguish between the phoneme-grapheme grammars of those children who do and do not have spelling difficulties. The phoneme-grapheme grammars of children with spelling difficulties may be more different to English phoneme-grapheme contingencies than those of children who do not have spelling difficulties. If this is the case, then one long term aim may be to base remediation of spelling difficulties on correcting the phoneme-grapheme grammar so that the child has phoneme-grapheme mappings which are closer to those in English. This would give them a phonetic basis upon which they can spell unknown words and those words whose spellings they are not sure of.

The aim in this study therefore is two-fold. The first is to show that children with spelling difficulties have a phoneme-grapheme grammar which they use consistently. The second aim is to show that the phoneme-grapheme grammars of children with spelling difficulties are not as close to English phoneme-grapheme mappings as those of children without spelling difficulties.

With these two aims in mind, two measures are required. The first is a measure of consistency and the second is a measure of closeness to English contingencies. In the last study, consistency was measured in terms of the number of pairs of nonword spellings in which the vowel grapheme was identical. In the present study, vowel phonemes are presented between 7 and 9 times in different nonwords. It is expected that children will select the highest contingency phoneme-grapheme mapping from their phoneme-grapheme grammar each time. Thus all incidences of the same vowel phoneme should be spelt with the same grapheme. Consistency is therefore measured as the proportion of occurrences of a phoneme accounted for by the most frequently used grapheme.

The 'closeness to English' of phoneme-grapheme mappings needs to be compared to some standard measure of English phoneme-grapheme mappings. Barry and Seymour (1988) used a position-independent count of how often a particular phoneme was spelt using a particular grapheme. This study uses their count, and also uses a position-sensitive count where the position of a phoneme in a word is taken into consideration.

For each count, the closeness to English of a child's phoneme-grapheme mappings can be measured in terms of the two most common mappings in English. If a child has a phoneme-grapheme grammar which is very close to English, it may be expected that they will select the most common graphemes in these counts. 'Closeness to English' is therefore measured as the proportion of graphemes selected by the child which are the same as the two highest contingency graphemes in English.

4.1.1 Summary of predictions

In comparing two groups of children, one with spelling difficulties and one without spelling difficulties, it is expected that:

(a) children with spelling difficulties are as consistent as children without spelling difficulties in the phoneme-grapheme mappings they use to spell vowel phonemes; and

(b) the phoneme-grapheme grammars of children with spelling difficulties are less like the phoneme-grapheme mappings found in English than those of children without spelling difficulties.

4.2 Method

4.2.1 Design

Two groups of children were used, one with spelling difficulties and one without spelling difficulties (the control group). The dependent variables were the consistency of the phoneme-grapheme mappings used, and the closeness to English of the phoneme-grapheme mappings used.

4.2.2 Subjects

The subjects were 24 children with a mean age of 10.4 years. The first 12 of these were selected on the basis of having spelling difficulties identified by a special needs teacher. They were all receiving extra reading and writing tuition. This group is called 'Group 1'. Each child in Group 1 was matched for age and sex with a child who did not have spelling difficulties, i.e. was not receiving extra tuition. The second group is called 'Group 2'. Reading ages were available for all the children, as measured on the Neale Analysis of Reading scale (Neale, 1958). No spelling age data was available for this study. The mean chronological age and mean reading age of both groups of children are shown in Table 4-1.

Chronological age		Reading age	
Group 1 (n=12)	**Group 2** (n=12)	**Group 1** (n=12)	**Group 2** (n=12)
10.4 (1.1)	10.4 (1.1)	8.3 (0.9)	10.5 (1.2)

TABLE 4-1. Mean chronological and reading ages of the subject groups in years (standard deviations in brackets)

As predicted, the mean reading age of Group 1 was lower than their mean chronological age ($t=10.629$, $df=11$, $p_{1\text{-tail}}<0.001$). Also, the mean reading age of Group 1 was lower than that of Group 2 ($t=7.479$, $df=11$, $p_{1\text{-tail}}<0.001$). The mean reading age of Group 2 was slightly higher than their mean chronological age ($t=2.896$, $df=11$, $p_{2\text{-tail}}<0.05$), indicating that these were children of above-average reading ability.

4.2.3 Materials

The vowel phonemes used in this study were the five 'long' vowel sounds: /ei/ (as in 'hay'), /iː/ (as in 'me'), /ai/ (as in 'pie'), /ou/ (as in 'go') and /uː/ (as in 'to'). The spelling of these vowel sounds are inconsistent, by Barry and Seymour's definition mentioned in Chapter 3, meaning that there are several ways in which each may be spelt in English text. Forty-two nonwords containing these vowel sounds were constructed. These were all monosyllabic and were of a consonant-vowel-consonant phonetic structure. The initial and terminal consonants were restricted to single phonemes rather than consonant clusters in order to make the task as easy as possible. For half the nonwords the terminal consonant was /d/, for the other half the terminal consonant was /t/. The terminal consonant of the nonwords was controlled in this way in case the presentation of a vowel phoneme next to different consonant phonemes affected the selection of a vowel grapheme. The final group of nonwords is shown in Table 4-2.

Vowel	Example	Nonword stimuli
/ei/	make	/deid/ /heid/ /keid/ /neid/ /teid/ /dʒeit/ /neit/ /peit/ /seit/
/iː/	seed	/djiːd/ /piːd/ /tiːd/ /diːt/ /dʒiːt/ /kiːt/ /liːt/ /riːt/
/ai/	fine	/faid/ /dʒaid/ /kaid/ /maid/ /naid/ /dait/ /dʒait/ /pait/
/ou/	rope	/doud/ /foud/ /dʒoud/ /poud/ /fout/ /dʒout/ /lout/ /pout/ /sout/
/uː/	food	/huːd/ /luːd/ /nuːd/ /tuːd/ /duːt/ /fuːt/ /nuːt/ /wuːt/

TABLE 4-2. Nonwords used in the study

Although some of these stimuli were possibly real words e.g. /luːd/ ('lewd'), it was thought that the children would not know a spelling for them and would consider them to be nonwords, to be spelt non-lexically. The list of nonwords was randomised for each subject so that each subject was presented with the nonwords in a different order. There were three constraints on the randomising process to mask the spelling of each nonword from the neighbouring nonwords. The first constraint was that nonwords ending in /d/ and /t/ were presented alternately. The second constraint was that no two nonwords containing the same vowel phoneme were presented consecutively, and the third constraint was that no two nonwords containing the same initial consonant phoneme were presented consecutively.

4.3 Procedure

Each subject was tested individually. They were told that they were to be given a list of nonwords which they should write down. It was emphasised that the words were not real words and so there was no right or wrong way of spelling them, but it was how they thought each one should be spelt that was important. Each nonword in the list was spoken aloud by the experimenter and repeated by the subject to make sure it had been heard correctly. They then wrote down how they thought it should be spelt and covered it up with a piece of paper. The next nonword was written on the line below.

4.3.1 Analyzing the data

For each child's spellings, all the nonwords containing the same vowel phoneme were grouped together. The vowel graphemes used to spell that phoneme were then identified. For this, it was assumed that the spelling of the terminal phoneme /d/ was either 'd' or 'dd', and the spelling of the terminal phoneme /t/ was 't' or 'tt'. Where another consonant letter was used next to these graphemes, it was ignored, e.g. 'fokt'. Any consonant letters occurring at the beginning of a nonword spelling were categorised as part of the initial consonant grapheme, e.g. 'ckeet'. Where a vowel letter followed the semi-vowel letter 'Y', this was also ignored, e.g. 'myid'. Two types of vowel grapheme were then identified. The first was a 'whole' grapheme, where the grapheme occurred between two sets of consonant letters. Examples of these are shown in Table 4-3.

Nonword spelling	Vowel grapheme
foud	ou
cad	a
dayd	ay
gett	e
ceet	ee
dyut	u

TABLE 4-3. Whole vowel graphemes

The second type of vowel grapheme was a 'split' grapheme, where the grapheme consisted of two or more letters and a consonant grapheme occurred between them. Examples of split graphemes are shown in Table 4-4.

Nonword spelling	Vowel grapheme
sate	a_e
gede	e_e
painte	ai_e
hoode	oo_e
doede	oe_e

TABLE 4-4. Split vowel graphemes

It was decided that where the first part of a split vowel grapheme consisted of two letters (e.g. 'oo_e') only these two letters should be counted as the grapheme (e.g. 'oo'). This is because in English words, the terminal 'e' usually acts as a syntactic marker following letters that do not generally occur at the end of words in English, e.g. 'breeze' and 'leave' (Baker, 1980). Sometimes the terminal 'e' has a dual function, serving also to lengthen pronunciation of the vowel sound which occurs before the consonant cluster, but this is considered only to be the case for split vowel graphemes where the first part has only one letter (e.g. 'rose').

4.3.2 Analyzing consistency

The consistency with which a child spelt each of the 5 vowel phonemes was measured in terms of the 5 graphemes used most frequently by the children. The proportion of occurrences of all the phonemes accounted for by the 5 most frequently used graphemes was calculated. For each child there were 42 occurrences of a vowel phoneme (i.e. 42 nonwords spelt). The number of times out of 42 accounted for by the most frequently used graphemes was converted to a percentage for each child. Thus the most consistent score which could be obtained was 100%, where only 5 graphemes had been used to spell the 5 vowel phonemes. The mean percentage consistency was then taken over each group of subjects and was therefore measured across all 5 vowel phonemes.

4.3.3 Analyzing 'closeness to English'

The closeness of each child's phoneme-grapheme mappings to those found in English was analyzed in terms of the two most common spellings in English. The first is the position-independent count used by

Barry and Seymour, and the second is a position-sensitive count derived for the purpose of this study.

4.3.3.1 A position-independent count

A position-independent measure of the frequencies of English phoneme-grapheme mappings has been computed by Barry and Seymour (1988). This count is considered to be 'position-independent' because it included words where the vowel phoneme occurred in an initial position (e.g. 'eat'), a medial position (e.g. 'feet') and a terminal position (e.g. 'tea'). For the five vowel phonemes used in the present study, the graphemes used in English to spell the phonemes are shown in Table 4-5.

Vowel	Most common spellings	Others
/ei/	late (43)	bass day they eight feint great
	wait (20)	reign fete straight gauge
/iː/	speak (40)	shriek me eke clique key ski
	seek (39)	Keith quay people foetal
/ai/	life (52)	cry pie high type dye dial
	mind (12)	buy eye height sign aisle
/ou/	dole (32)	bowl coal toe folk soul owe
	droll (26)	sew dough mauve brooch yeoman
/uː/	moon (48)	crude you flu glue do fruit
	screw (10)	shoe move ewe through sleuth

TABLE 4-5. Position-independent frequencies of the spelling patterns of five vowel phonemes (taken from Barry and Seymour, 1988)

These graphemes are shown in the context of real words which contain the graphemes. Also shown in the table are the proportion of occurrences of a phoneme accounted for by the two most common graphemes. The most common graphemes for each phoneme are referred to as 'high contingency' phoneme-grapheme mappings.

Alongside the 2 most common spellings are examples of words containing less common spellings. Note that the real words contain examples where the vowel phoneme occurs in initial, medial and terminal position. For example, the vowel phoneme /ei/ occurs in initial position in the word 'eight', medial position in the word 'feint', and terminal position in the word 'day'. Because this count has been based on words in which the phoneme can occur in any position, it is referred to in this thesis as a 'position-independent' count.

4.3.3.2 A position-sensitive count

In addition to the position-independent count, another measure of 'closeness to English' was taken. This consisted of a context-sensitive count of phoneme-grapheme mappings. For some phonemes, the position of the phoneme appears to determine the grapheme which is used in a word. For example, the two most common spellings for the vowel phoneme /ai/ in the position-independent count were 'i_e' (as in 'life') and 'i' (as in 'mind'). In this count, both these graphemes are presented in a medial position within a word; that is, the vowel phoneme occurs between two consonant phonemes or consonant clusters. However, the most common graphemes for this phoneme when it occurs in terminal position are 'ie' (as in 'pie') and 'y' (as in 'my'). These graphemes rank fairly low when a survey of phonemes in all positions are considered. Therefore in comparing phoneme-grapheme mappings to those found in English, it may be appropriate to use a position-sensitive count of English phoneme-grapheme mappings as a standard. For this reason a second count of phoneme-grapheme mappings was taken for occurrences of the 5 vowel phonemes where they occur in medial position only.

A battery of 799 monosyllabic words was made up, consisting of all words known to the author containing a vowel phoneme, where this phoneme occurred between two consonant phoneme clusters. A consonant phoneme cluster could consist of either a single consonant phoneme (as in 'raid') or more than one consonant phoneme (as in 'straight'). Regular inflections of words, for example past participles such as 'sailed', were not included. However, irregular inflections, for example past participles such as 'paid', were included. The words used for the phoneme-grapheme mapping count are listed in Appendix B. The two most common spellings for phonemes occurring in medial position are shown in Table 4-6, alongside the frequency with which each grapheme is used to spell each phoneme.

Vowel	Most common graphemes	Frequency (%)	Example
/ei/	a_e	70.4	late
	ai	23.8	wait
/iː/	ea	47.6	speak
	ee	39.8	seek
/ai/	i_e	76.6	life
	igh	9.0	light
/ou/	o_e	54.0	dole
	oa	22.3	soap
/uː/	oo	52.7	moon
	u_e	22.7	June

TABLE 4-6. Position-sensitive frequencies of the spelling patterns of the vowel phonemes in medial position

The two most common phoneme-grapheme mappings for the vowel phonemes using both the position-independent and the position-sensitive count are shown together in Table 4-7 for comparison. It can be seen that while the most common grapheme is the same for all 5 phonemes, the second most-common grapheme is different for 3 of them (/ai/, /ou/ and /u:/).

	Position- independent		Position-sensitive	
Vowel	Grapheme	e.g.	Grapheme	e.g.
/ei/	a_e	late	a_e	late
	ai	wait	ai	wait
/i:/	ea	speak	ea	speak
	ee	seek	ee	seek
/ai/*	i_e	life	i_e	life
	i	mind	igh	light
/ou/*	o_e	dole	o_e	dole
	o	droll	oa	soap
/u:/*	oo	moon	oo	moon
	ew	screw	u_e	June

TABLE 4-7. Two most common spellings in English using a position-independent and a position-sensitive count (*denotes different graphemes in each count)

4.3.3.3 Using the two counts

The phoneme-grapheme mappings used by the children were analyzed for their closeness to English in terms of both the position-independent and the position-sensitive count. For each child, the number of graphemes used which were one of the two most common English spellings was counted. This number was out of 42 possible spellings, and was converted to a percentage. The mean percentages were then taken for each of the two groups of children (those with spelling difficulties, and the control group). A score of 100% would mean that all the graphemes selected by a child were the highest contingency mappings found in English. This would mean that the child's phoneme-grapheme grammar was very close to English phoneme-grapheme mappings.

4.4 Results

The consistency of the phoneme-grapheme grammars and their closeness to English were analyzed across all five vowel phonemes. The two graphemes used most frequently for each of the 5 vowel phonemes are shown in Table 4-8. They are shown separately for each group of subjects, where Group 1 is the children with spelling difficulties and Group 2 is the control group. Also shown in Table 4-8, for comparison, are the two most common English spellings in the two counts.

The most frequently used grapheme was the same for both subject groups, for each vowel phoneme. Furthermore, for 4 out of 5 vowel phonemes, the most frequently used grapheme was the same as the most common position-independent spelling in English. For the fifth vowel phoneme, /iː/, the most frequently used grapheme is 'ee', which is the second most common position-independent English spelling. However, the most common position-independent spelling, 'ea', occurs in 40% of words, and 'ee' in 39% of words (see Section 4.3.3.1). Because they occur with practically the same frequency in English, the graphemes 'ee' and 'ea' may be regarded equally as the most common spelling. Thus we may conclude that the most frequently used graphemes in this study are also the most common position-independent spellings in English. This performance is similar to that of adults who also use the most common position-independent English spellings when spelling nonwords (Barry and Seymour, 1988).

	(a) English spellings		(b) Children's spellings	
Vowel	P-Independent	P-Sensitive	Group 1	Group 2
/ei/	a_e	a_e	a_e	a_e
	ai	ai	a	ai
/iː/	ea	ea	ee	ee
	ee	ee	e	ea
/ai/	i_e	i_e	i_e	i_e
	i	igh	i	i
/ou/	o_e	o_e	o_e	o_e
	o	oa	o	oa
/uː/	oo	oo	oo	oo
	ew	u_e	o	o_e

TABLE 4-8. The two phoneme-grapheme mappings (a) occurring most commonly in English, and (b) used most frequently in the study

The two subject groups appear to differ in terms of the second most frequently used grapheme. For 4 out 5 vowel phonemes, the second most frequently used grapheme is different for Group 1 and Group 2. This is analyzed in more detail below (see Section 4.4.3.1).

4.4.1 Consistency

The mean consistency ratings of Groups 1 and 2, measured as a percentage, are shown in Table 4-9.

Group 1 (Children with spelling difficulties) (n=12)	Group 2 (Controls) (n=12)
69.7 (16.3)	58.9 (11.7)

TABLE 4-9. Mean percentage consistency (standard deviations in brackets)

The consistency of Group 1 tended to be higher than that of Group 2, although this difference was not significant (t=2.193, df=11, n.s.). Thus it appears that children both with and without spelling difficulties are not significantly different in their consistency in their selection of their highest contingency phoneme-grapheme mappings when spelling nonwords. The slight difference suggests that children with spelling difficulties (Group 1) may be less sensitive to alternative spellings of a phoneme, relying excessively on a single, context-insensitive phoneme-grapheme mapping.

4.4.2 Closeness to English

4.4.2.1 Position-independent count

The percentage of graphemes used which were the same as the two most common position-independent graphemes in English are shown in Table 4-10. There was no significant difference in the closeness to English phoneme-grapheme mappings between Group 1 and Group 2 ($t=0.397$, $df=11$, $p_{1\text{-tail}}=0.350$, n.s.). The variance within Group 1 (children with spelling difficulties) was almost twice as high as the variance within the control group.

Group 1 (Children with spelling difficulties) (n=12)	Group 2 (Controls) (n=12)
56.8 (22.5)	59.5 (11.3)

TABLE 4-10. Percentage closeness to English (standard deviations in brackets)

This suggests that the first group is not as homogeneous as the second, and this suggestion is confirmed by the idiosyncratic use of alternative strategies in nonword spelling (see Section 4.4.3).

4.4.2.2 Position-sensitive count

The percentage of graphemes used which were the same as the two most common medial spellings in English are shown in Table 4-11.

Group 1 (Children with spelling difficulties) (n=12)	Group 2 (Controls) (n=12)
47.0 (30.0)	67.0 (16.0)

TABLE 4-11. Percentage closeness to English (standard deviations in brackets)

The graphemes used by Group 2 (children without spelling difficulties) were closer to English than those used by Group 1 (children with spelling difficulties) ($t=2.000$, $df=11$, $p_{1\text{-tail}}<0.05$). This difference was as predicted. Interestingly, the variance within Group 1 (children with spelling difficulties) is again almost twice the variance within the control group.

4.4.3 A qualitative analysis

During analysis of the data it appeared that four other strategies were occasionally being used to spell the nonwords, and that this could partly account for the differences in variance between the two groups. These strategies were spelling by letter-name, lexical parsing, morphemic spelling and context-sensitive spelling.

4.4.3.1 Spelling by letter-name

It was noticed during the initial classification of the graphemes used by each group that there was a difference between the two groups in terms of the second most frequently used grapheme. These graphemes and the frequency with which they are used are shown in Table 4-12.

	Group 1 (Ch. with sp. difficulties)		**Group 2 (Controls)**	
Vowel	Grapheme	Freq (%)	Grapheme	Freq (%)
/ei/	a	25	ai	18.5
/i:/	e	37.5	ea	18.8
/ai/	i	33.3	i	5.2
/ou/	o	26.9	oa	29.6
/u:/	o	15.6	o_e	13.5

TABLE 4-12. The second most frequently used graphemes and the frequency with which they were used

For 4 out of 5 vowel phonemes, the second most frequently used grapheme in Group 1 (children with spelling difficulties) is the letter-name which is that vowel sound. This means that /ei/ was spelt with the letter 'A', /iː/ with the letter 'E', /ai/ with the letter 'I', and /ou/ with the letter 'O'. For example, /neit/ (rhymes with 'fate') was spelt 'nat' and /diːt/ (rhymes with 'feet') was spelt 'det'. The exception is the vowel /uː/. This is slightly different from the letter-name 'U' which is pronounced with the initial semi-vowel /j/, i.e. /juː/, and may be why this letter-name was not used. If this vowel sound had been presented in a nonword alongside the semi-vowel, e.g. /pjuːt/ (rhymes with 'cute'), it is possible that the letter-name 'U' would have been used more often.

By comparison, a letter-name was only used by Group 2 (children without spelling difficulties) for the vowel sound /ai/. In the position-independent count of common English spellings, the letter 'I' also happens to be the second most common spelling of this phoneme anyway, as in 'mind' or 'mild'. So it is possible that the children in Group 2 were not using the letter-name to spell this phoneme; rather they were using the second most common sound-to-spelling mapping in English. This would be consistent with some of the other second most frequently used graphemes for this group: /ei/ was spelt 'ai' (as in 'aid') and /iː/ was spelt 'ea' (as in 'eat'). Also, /ou/ was spelt 'oa' (as in 'soap'). While this is not the second most common spelling in the position-independent count of sound-to-spelling mappings, it is the second most common spelling in the position-sensitive count. Therefore it appears that the second most frequently used spelling for Group 2 was the second most common English spelling, but for Group 1 was a letter-name.

However, it is possible that the spelling of some of these vowel phonemes were not letter-name spellings at all, but were attempts to spell using a high contingency English phoneme-grapheme mapping. These graphemes contain a silent 'E' which is supposed to be written after the consonant grapheme, e.g. 'a_e' in 'late', 'i_e' in 'life'. In the course of writing the nonword, the silent 'E' may be omitted. This would cause 'late' to be spelt 'lat', and 'life' to be spelt 'lif'. Such spellings have often been categorised as 'omissions' rather than 'letter-name spellings'. However, one reason why the data are thought to be letter-name spellings rather than omissions is that the vowel phoneme /iː/ is frequently spelt 'e' by the children. If this was an omission, the intended grapheme would have to have been 'e_e' (as in 'theme' or 'these'). This is a very uncommon spelling for this phoneme in English and so it is unlikely that a child would attempt to use it. It is more likely that the spelling 'e' represented the use of the letter-name 'E'.

Another difference between the two subject groups in terms of the second most frequently used graphemes was that Group 1 appeared to rely more heavily on the second grapheme than Group 2. For 4 out of the 5 vowels, the second grapheme is used in more nonwords by Group 1 than by Group 2. The overall use of letter-name spellings was compared by counting the number of times out of 42 that each child used a letter-name spelling in a nonword. Although 'U' is not strictly a letter-name spelling of the phoneme /uː/, this was included in the count. The mean number of letter-name spellings for each group are shown in Table 4-13.

Although Group 1 used more letter-name spellings than Group 2 overall ($t=2.526$, $df=11$, $p_{1\text{-tail}}<0.05$), neither group was consistent enough in using, or not using, letter-name spellings to make this comparison very meaningful. One of the children without spelling difficulties made 13 out of a possible 42 letter-name spellings, and three of the children with spelling difficulties did not use letter-name spellings at all.

Group 1 (Children with spelling difficulties)	Group 2 (Controls)
(n=12)	(n=12)
9.0 (8.9)	2.2 (3.7)

TABLE 4-13. Mean number of letter-name spellings out of 42 (standard deviations in brackets)

4.4.3.2 Lexical parsing

Lexical parsing was first described by Campbell (1983) who suggested that nonwords may be spelt using a real word which formed part of the nonword. Barry and Seymour (1988) failed to replicate any effect of lexical parsing. However, a number of nonword spellings in this study appeared to be based on the spelling of a real word embedded in the nonword. The most common example was the spelling of the nonword /deid/ as 'dayd' or 'dayed'. The grapheme 'ay' is rarely used in real words when it occurs in a medial position, although it is quite common in a terminal position, e.g. 'day' and 'hay'. The nonword /deid/ therefore appears to have been frequently spelt using the word 'day'.

An argument against this would be that the child's highest contingency phoneme-grapheme mapping for /ei/ is 'ay'. If this was the case, we would not need to account for the nonword spelling in terms of lexical parsing. If this phoneme-grapheme mapping had been used, we may also expect that the other nonwords containing this phoneme would be spelt with the same grapheme, e.g. /neit/ would be spelt 'nayt' and /teid/ would be spelt 'tayd'. This was not the case, however, since 7 children (5 in Group 1 and 2 in Group 2) who used this grapheme for /deid/ and /heid/ used it for these words exclusively, using other graphemes when the phoneme /ei/ occurred in other nonwords. It therefore appeared that lexical parsing may have been used for these nonwords.

Another nonword which was often spelt using an uncommon grapheme, and whose grapheme differed from the rest of the graphemes used for that phoneme, is /maid/ (rhymes with 'hide'). This was spelt using the embedded word 'my' by 7 children, 5 of whom were in Group 1 and 2 of whom were in Group 2. The various spellings were 'myd', 'myed', 'myde' and 'myid'. Other nonwords which may have been spelt by lexical parsing were /hu:d/ (rhymes with 'food') spelt 'whod' and 'whoed', and /tu:d/ (rhymes with 'food') spelt 'twoed'. However, these spellings did not occur often enough to suggest that this strategy was used consistently by any child.

4.4.3.3 Morphemic spelling

Some children appeared to spell the terminal consonant phoneme /d/ as the past participle morpheme 'ed'. This was most apparent when the vowel grapheme involved the letter 'y', effectively separating the vowel grapheme and the consonant grapheme. For example, when the nonword /deid/ was spelt using the grapheme 'ay', the nonword was sometimes spelt 'dayd' and sometimes spelt 'dayed'. In the latter, it is possible that the vowel grapheme was 'aye', but since this never occurs in English it was thought more likely that the vowel grapheme was 'ay' and that the consonant grapheme used for /d/ was 'ed'. Other nonwords where the 'ed' grapheme followed a 'y' were /maid/ spelt 'myed', /keid/

spelt 'kayed', /teid/ spelt 'tayed', /heid/ spelt 'hayed' and /kaid/ spelt 'kyed'.

For some nonwords it was possible that the terminal consonant phoneme was spelt 'ed', but there was no clear separation between the vowel grapheme and the consonant grapheme. For example, where /dʒaid/ was spelt 'jied', the letter 'E' could have been part of a vowel grapheme 'ie' and also part of the terminal consonant grapheme 'ed'. Thus these spellings could only be regarded as possible uses of the morpheme 'ed'. Other possible morphemic spellings were /doud/ spelt 'doed', /foud/ spelt 'foed', /deid/ spelt 'daed', /faid/ spelt 'fied' and /maid/ spelt 'mied'. Again, these spellings did not occur often enough to suggest that a child used morphemic spellings with any regularity.

4.4.3.4 Context-sensitive spelling

The nonwords in this study were presented with two terminal consonant phonemes: /d/ and /t/. Some children appeared to be sensitive to this contextual information when selecting a grapheme for the preceding vowel phoneme. This was most apparent in two subjects where one grapheme was consistently selected when followed by /d/, and another was consistently selected when followed by /t/. In the first case, the nonword ending /eid/ was spelt 'ayd' (in 4 nonwords), whereas the ending /eit/ was spelt 'ate' (in 4 nonwords). In the second case, the ending /aid/ was spelt 'ide' (in 5 nonwords), whereas the ending /ait/ was spelt 'ight' (in 3 nonwords). These two instances occurred in two separate children.

19 other children spelt at least one vowel phoneme 100% consistently when followed by one ending, and inconsistently when followed by the other. For example, one child consistently spelt the nonword ending

/oud/ (rhymes with 'code') as 'ode', using the grapheme 'o_e', but spelt the ending /out/ (rhymes with 'coat') as 'oat' and 'out', using the graphemes 'oa' and 'ou'.

4.5 Discussion

One aim of the second study was to show that children with and without spelling difficulties are equally consistent in their phoneme-grapheme mappings. A second aim was to show that children with spelling difficulties differed from children without spelling difficulties in terms of the phoneme-grapheme mappings they used. By presenting several nonwords containing the same vowel phoneme, it was shown that children with spelling difficulties were as consistent as those without spelling difficulties in the phoneme-grapheme mappings they select. It was also shown that the phoneme-grapheme mappings they have are less like English phoneme-grapheme mappings than those of children without spelling difficulties. However, the study also showed that children could use whole real words, letter-names and morphemes to spell nonwords, and that selection of a grapheme was sometimes dependent on the context in which a phoneme was presented. Furthermore, it appeared that children's phoneme-grapheme mappings were more easily explained in terms of a position-sensitive count of English phoneme-grapheme mappings.

This suggests that in identifying a child's phoneme-grapheme grammar, the grammar should be expected to be position-sensitive. Rather than describing spellings used for isolated phonemes, a child's phoneme-grapheme grammar should aim to describe the spellings of the phonemes as they occur in different contexts. The first type of context which should be included is the position of the phoneme in a syllable, i.e. whether it occurs in an initial, medial or terminal position. Since the spellings of phonemes in English vary in this way, the phoneme-grapheme grammar of an adult is likely to take account of the position of a phoneme.

The second type of context is the phonemes which surround a phoneme. The grammar should be able to show that a phoneme may be spelt differently when preceded or followed by particular phonemes. This means that a non-lexical store may contain phoneme strings which are larger than a single phoneme. These phoneme strings would then be stored with their spellings which would contain more than one grapheme. The idea of a non-lexical store containing units larger than an individual phoneme has also been suggested for reading (Marcel, 1980; Shallice, Warrington and McCarthy, 1983). The idea of such a store for spelling has also been suggested in a brain-damaged adult who knew that the ambiguous vowel phoneme /ɜː/ (as in 'bird', 'heard', 'word' and 'third') is likely to be spelt 'or' when following the phoneme /w/ (as in 'word' and 'world') (Baxter and Warrington, 1987).

Although a non-lexical store may contain phoneme-strings, this does not explain how whole words and morphemes such as the past-participle morpheme 'ed' may be used, since these are thought to be stored separately in the lexicon (Ellis, 1982). If real words and morphemes can be used to spell nonwords, this suggests that the two routes of spelling in the dual-route model, the lexical route and the non-lexical route, may be interactive. This is examined in more detail in Chapter 6.

Because of the individual differences observed in nonword spellings, it appeared that the individual phoneme-grapheme grammars of children with spelling difficulties need to be examined in order to pinpoint strategies used by individual children, and the specific phoneme-grapheme mappings they have which are either of low contingency or completely unlike those found in English. The next chapter describes a study which aims to identify the phoneme-grapheme grammars of individual children with spelling difficulties.

4.6 Conclusions

This study showed that children with spelling difficulties are as consistent as children without spelling difficulties in terms of the consistency with which they use particular phoneme-grapheme mappings to spell nonwords. However, the phoneme-grapheme mappings of children with spelling difficulties were found to be less like English mappings than those of children without spelling difficulties, using a position-sensitive count of English phoneme-grapheme mappings. It was suggested that position-sensitive counts may be more useful than position-independent counts in assessing children's phoneme-grapheme grammars - this is tested in Chapter 5. Children were also found to use other strategies, including spelling by letter-name, lexical parsing, morphemic spelling and context-sensitive spelling. Morphemic spelling is investigated in Chapters 6, 7 and 8.

CHAPTER 5

The phoneme-grapheme grammars of children with spelling difficulties

5.1 Introduction

In Chapter 4 it was found that children with spelling difficulties used phoneme-grapheme mappings consistently when spelling nonwords. It was also found that the mappings they used were less like those in English than the mappings of children without spelling difficulties. In this chapter, individual children are studied more closely in order to gain detailed information about their phoneme-grapheme grammars. By presenting a battery of nonwords containing vowel phonemes in different contexts, we can identify the specific phoneme-grapheme mappings which differ from those found in English.

Although the previous study also examined children's spelling of nonwords, it differs from the study reported in this chapter in two ways. The first difference is in the methodology used. In Chapter 4, children were examined in groups, and the average performance of one group was compared to the average performance of the control group. In this study, however, a corpus of nonword spellings are collected from several children, and three case reports described. A second way in which this study differs is in the nonword stimuli used. In Chapter 4, children were presented with nonwords containing vowel phonemes in medial position only. This means that the vowel phoneme in a nonword was both preceded and followed by a consonant phoneme, e.g. /pu:t/ (rhymes with 'boot'). However in this study, vowel phonemes are presented in three different positions: initial, medial and terminal. Because phonemes are often spelt differently when they occur in different positions in real words, it was expected that children may be aware of this difference when spelling nonwords.

In order to assess whether it is reasonable to expect a child to spell a phoneme differently when it occurs in different positions, we need to be able to compare the child's spellings to common spellings of the phoneme in real words. It was noted in Chapter 4 that the count of common English spellings taken by Barry and Seymour (1988) included vowel phonemes in all three positions, and did not discriminate between them, i.e. theirs was a position-independent count. Thus, although the most common spellings are useful overall, they do not tell us about the most common English spellings in specific positions. A report by Hanna, Hanna, Hodges and Rudorf (1966) calculated the frequency with which phoneme-grapheme mappings occur in different positions in English text, but this is not the same as the frequency with which they occur in English words and so could not be used in this thesis. The study in Chapter 4 included another count of the spelling of vowel phonemes for when they occur in medial position in real words, i.e. when they are preceded by and followed by a consonant cluster. In this chapter, two further counts are taken to establish the most common spellings for vowel phonemes when they occur in initial and terminal positions. This is to enable a meaningful comparison between a child's spellings and those found in English.

5.2 Method

The aim of the study was to identify the phoneme-grapheme grammars of individual children for the five vowel phonemes used in the previous study: /ei/ as in 'pay', /i:/ as in 'pea', /ai/ as in 'pie', /ou/ as in 'go' and /u:/ as in 'two'. These would be described in terms of the consistency with which they are used to spell each phoneme when it occurs in a nonword. The phonemes were to be presented in monosyllabic nonwords for writing to dictation.

It was expected that the way individual children would spell the phonemes may be different for different positions in a nonword. Thus /ei/ may be spelt one way when it occurs at the beginning of a nonword such as /ein/ (which rhymes with 'rain'), but spelt another way when it occurs at the end of a nonword such as /tei/ (which rhymes with 'day'). This was expected because the spelling of these sounds in real words sometimes differs according to the position of the sound. For example, the sound /ei/ is most often spelt 'ay' when it occurs at the end of a monosyllabic word, such as 'day', 'pay', 'hay', 'ray', 'say', but this spelling is never used in the middle of a monosyllabic word, i.e. when the vowel phoneme is followed by a consonant phoneme. In this position, the graphemes 'ai', 'eigh' or 'a_e' are more likely to be used, e.g. 'rain', 'weight', 'gate'. It is therefore thought that the phoneme-grapheme mappings for a particular phoneme should be able to take the position of a phoneme into account.

5.2.1 Subjects

30 children aged 9 and 10 participated in the study. They were each selected by their teachers as having difficulties with spelling, although none had problems severe enough to warrant extra tuition.

5.2.2 Materials

A battery of nonwords was prepared. As many nonwords as possible containing each of the 5 vowel phonemes /ei/, /i:/, /ai/, /ou/ and /u:/ were needed in order to find out how a child thinks that that phoneme is spelt in different contexts. This was in order to establish that a child had spelt a vowel phoneme by associating it with a grapheme, rather than by spelling it in a particular way by chance.

In order to generate a large number of monosyllabic nonwords, all possible phonetic sequences containing the vowel phoneme in a monosyllabic structure were generated by computer. Following this, all those which were real words were deleted to leave a battery of nonwords.

Only monosyllabic structures were included in the study in order to control for the effect of syllable position. For example, the vowel sound /ei/ in the word 'wade' is spelt with the grapheme 'a_e'; however, in the word 'wading' we may say that it is spelt with the grapheme 'a'. On the other hand, we may say that the grapheme for /ei/ in 'wading' is 'a_e' but that on concatenation of the morphemes 'wade' and 'ing', the grapheme is abbreviated to 'a' according to conventional rules about concatenating morphemes where the terminal 'e' is dropped from the first morpheme. Thus the grapheme 'a' may be said to be the result of the process of concatenating morphemes, rather than being simply the chosen grapheme for the phoneme /ei/. The study was restricted to monosyllabic structures to avoid this confusion.

In monosyllabic real words, consonant phonemes usually occur either on their own, or as two consectutive phonemes (a 'diphone'). Single consonant phonemes, for example, would be /θ/ at the beginning of the word 'thin', and /d/ at the end of the word 'aid'. Note that although the phoneme /θ/ is spelt with two letters, it is only one phoneme (it cannot be broken down into smaller discernible sound units) and the two letters therefore constitute one grapheme: 'th'. Examples of consonant diphones occurring in monosyllabic words would be /kw/ at the beginning of the word 'quick'and /tʃ/ at the end of the word 'itch'. The diphone /tʃ/ also occurs at the end of the word 'rich'; thus it is not possible to state categorically which phoneme in the diphone, /t/ or /ʃ/, is represented by which grapheme, 't' or 'ch', since the same diphone is spelt differently in both words ('tch' and 'ch'). This is one problem which occurs when using the definition of a grapheme to mean a letter or letters which represents a phoneme (see Henderson, 1986, for alternative definitions of a grapheme). However, it is possible to say that both the words 'itch' and 'rich' end in the two consonant phonemes /t/ and /ʃ/.

Consonant phonemes can also occur consecutively in groups of more than two, e.g. the three phonemes /s/, /t/ and /r/ at the beginning of the word 'strong', although groups this size are considerably less frequent than diphones and single phonemes. However, the size of a group of consecutive consonant phonemes does not affect the number of syllables in a word unless the phonemes are separated by a vowel phoneme. Thus the word 'strengths' has three initial consonant phonemes (/s/ + /t/ + /r/)

followed by a vowel phoneme (/e/) followed by three consonant phonemes (/ŋ/ + /θ/ + /s/) and yet has only one syllable, as does a word with single initial and terminal consonant phonemes, e.g. 'paid' (/p/ followed by /ei/ followed by /d/).

The syllabic structure of a word or nonword, then, is independent of the number of consonant phonemes in a group, but is dependent on the overall number of groups. There are three types of phonetic sequence which produce a monosyllabic nonword, using vowel phonemes and consonant phoneme groups in different relative positions. The three types of phonetic structure are described below.

5.2.2.1 The nonword structures

(a) Vowel + Consonant (VC)

The VC structure consists of a vowel phoneme followed by a consonant phoneme group (one or more consonant phonemes). Examples of real words with this phonetic structure are 'oat' (/ou/ + /t/), 'itch' (/i/ + /tʃ/) and 'age' (/ei/ + /dʒ/). Some nonwords with this phonetic structure would be /eiv/ (rhymes with 'save'), /ouz/ (rhymes with 'goes') and /u:θ/ (rhymes with 'tooth'). The vowel phoneme in this structure is in the initial position.

(b) Consonant + Vowel (CV)

The vowel phoneme in the CV structure follows a consonant group and so occurs in the terminal position. Examples of real words with this phonetic structure are 'lie' (/l/ + /ai/), 'stay' (/st/ + /ei/) and 'me' (/m/ + /i:/). Some nonwords with this structure would be /vou/ (rhymes with 'go'), /kwei/ (rhymes with 'day') and /dʒai/ (rhymes with 'sky').

(c) Consonant + Vowel + Consonant (CVC)

Words and nonwords with this structure contain a vowel phoneme which occurs in between two consonant groups. Thus the vowel phoneme is in a medial position. Some words with this structure are: 'made' (/m/ + /ei/ + /d/), 'thing' (/θ/ + /i/ + /ŋ/) and 'stripe' (/str/ + /ai/ + /p/). Some nonwords with this structure would be /mu:l/ (rhymes with 'fool'), /vi:s/ (rhymes with 'geese') and /taiv/ (rhymes with 'hive').

Note that all of these three structures denote the phonetic content of a word or nonword, and not its spelling. Thus although the word 'day' is spelt with a consonant letter ('D') followed by a vowel letter ('A') followed by a consonant letter ('Y'), its phonetic structure is CV (/d/ + /ei/) where the consonant phoneme /d/ is represented by the grapheme 'd' and the vowel phoneme /ei/ is represented by the grapheme 'ay'.

5.2.2.2 Generating the nonwords

5.2.2.2.1 Sets of phonemes

A computer program was written to generate all permutations of a given set of vowel and consonant phoneme groups in each of the three phonetic structures. The three sets of phonemes input into the program were as follows:

(1) Initial consonant phoneme groups: Total = 23

/b, d, f, g, h, dʒ, k, l, m, n, p, r, s, t, v, w, y, z, tʃ, kw, ʃ, θ, ð/

(2) Vowel phonemes: Total = 5

/ei, i:, ai, ou, u:/

(3) Terminal consonant phoneme groups: Total = 18

/b, d, f, g, dʒ, k, l, m, n, p, s, t, v, z, tʃ, ʃ, θ, ð/

Note that a consonant phoneme group refers to either one phoneme e.g. /d/ and /θ/, or a diphone, e.g. /kw/ and /tʃ/. No groups of more than two consonant phonemes were used. The sets of initial and terminal consonant phonemes were different because some consonant phonemes which occur in initial positions do not occur in terminal positions. Some examples of these are the aspirated /h/ at the beginning of 'head', and /kw/ at the beginning of 'quick'. Thus, the terminal phonemes were essentially a subset of the set of initial consonant phonemes.

5.2.2.2.2 The computer program

The program was then run to produce all monosyllabic permutations of these phonemes, in each of the three phonetic structures (CV, VC and CVC). This resulted in the following number of phoneme strings for each structure:

- CV = 115 (23 consonants x 5 vowels)
- VC = 90 (5 vowels x 18 consonants)
- CVC = 2070 (23 consonants x 5 vowels x 18 consonants)

A total of 2275 monosyllabic phoneme strings were produced.

5.2.2.2.3 Removing the real words

Since this list contained real words as well as nonwords, all the real words had to be removed. The point of removing all the real words was that the stimuli needed to be unfamiliar to the children, so that they would not have any lexical representation for the spelling of the words, and would have to spell them using phoneme-grapheme mappings. For some words, e.g. slang words such as 'oof', it was possible that a child would have some notion of how they should be spelt having maybe seen them written in comics for example. Thus all possible slang words, American pronunciations of words and real names were deleted.

The process of deleting the real words was carried out by two judges (RS and COM) who independently scanned all 2275 phoneme strings, marking those they considered to be real words. After the first pass, a total of 705 words had been marked: 470 of these had been marked by both judges, 158 had been marked by RS only, and 77 had been marked by COM only. Hence the judges agreed on 66.7% of all the words marked (470 out of 705). Inclusion of the remaining words, which had been marked by one judge but not the other, was discussed until agreement had been reached on all of them. The final number of real words deleted was 670. Out of the original 2275 phoneme strings, this left 1605 which were to be used as nonwords in the study.

It was decided that this was too many nonwords to give to a child to spell, so some of these nonwords were also removed. These were all phoneme strings that included the consonant phoneme groups /ʃ/, /θ/, /ð/, /tʃ/ and /kw/. These were selected because they are commonly spelt with more than one letter when they occur at the beginning of a word; that is, /ʃ/ spelt 'sh' as in 'ship', /θ/ spelt 'th' as in 'thin', /ð/ spelt 'th' as in 'this', /tʃ/ spelt 'ch' or 'tch' as in 'rich' or 'itch', and /kw/ spelt 'qu' as in 'quick'. The remaining consonant phonemes, including one diphone (/dʒ/) are usually spelt with one letter, including the diphone /z/ which is usually spelt either 'g' as in 'gin' or 'j' as in 'jug'. It was thought that these remaining consonant phonemes would be easier for children to spell, and would be less likely to detract their attention from spelling the vowel sounds.

The remaining list then contained 854 nonwords. Table 5-1 shows, for each phonetic structure, how many nonwords there were and what proportion this was out of the total number of phoneme strings which were words and nonwords. The table also shows how many nonwords there were on average for each of the 5 vowel phonemes; this is simply the total number of nonwords divided by 5. It can be seen that a relatively low proportion of CV phoneme strings were nonwords (21 out of 115) since most phoneme strings with a CV structure are real words, e.g. 'bee', 'day', 'sew', 'fee', 'lie' etc. This meant that there were, on average, only four nonwords for each vowel phoneme, where that phoneme occurred in a terminal position. For example, the vowel phoneme /ai/ (as in the word 'lie') occurred in terminal position in the following nonwords only: /dʒai/, /kai/, /jai/ and /zai/.

Structure	Total (words + nonwords)	Nonwords	Example	Percentage of total	Average no. per vowel phoneme
VC	90	41	/aif/	45.6%	8
CVC	2070	792	/nuːm/	38.3%	158
CV	115	21	/zai/	18.3%	4

TABLE 5-1. Distribution of nonwords in the complete word list

One of the expectations of the study was that a vowel phoneme occurring in a terminal position may be spelt differently to a vowel phoneme in initial or medial position. However, since there were so few nonwords containing a vowel phoneme in a terminal position this meant that any difference between its spelling in different positions would not be conclusive. Despite this, the CV nonword stimuli were retained just in case any differences were observed.

5.2.2.3 Constructing individual lists

This final set of 854 nonwords was ordered into a list for each child. A differently ordered list was used for each child in case any effect of ordering occurred in the nonword spelling. To take an extreme hypothetical example, this could mean that if most of the nonwords containing the vowel phoneme /ei/ occurred near the end of the list, all the children may have been bored at this point and simply guessed a random spelling for those nonwords. This would show up in the data as the vowel phoneme /ei/ having a very large, and inconsistent number of graphemes associated with it, when really it would be the case that any of the vowel phonemes occurring near the end of the list would be characterised by the same pattern of spellings.

The nonwords in each list were ordered randomly, but with the following constraints:

(i) no two nonwords could occur consecutively if they contained the same vowel phoneme, e.g. /vou/ and /oudʒ/;

(ii) no two nonwords could occur consecutively if they contained the same initial consonant, e.g. /zei/ and /zai/;

(iii) no two nonwords could occur consecutively if they contained the same terminal consonant, e.g. /iːs/ and /ous/.

These constraints were to mask the spelling of each nonword from the spelling of the previous nonword. This was because in the study reported in Chapter 3 it had been noticed that when words containing the same vowel sound had been written consecutively, some children had copied the spelling of the vowel sound each time from the spelling in the previous word.

5.2.3 Procedure

Each child was seen individually over a period of two weeks. For each child, the list of nonwords was divided into 6 blocks of about 140 nonwords; each time the child was seen, one block of nonwords was written to dictation. In each session, the author would say each nonword out loud. The child would repeat it and write down how they thought it might be spelt, as quickly as possible. They would then cover the spelling with a piece of card, ready to write the next nonword on the next line down. Completing one block (about 150 words) usually took 15-30 minutes.

Occasionally, only half a block (75 words) would be completed in one session, and the child would return later in the day to complete it. At other times, due to absence, a child might complete a single block plus an outstanding block in one day in two or three sessions. Sometimes, a child would complete a whole block (150 words) in one session. This was rare, as such highly intensive writing made several children's hands or arms ache.

5.2.4 Analysis

5.2.4.1 A position-sensitive count for initial and terminal position

A count was taken of the most common spellings of the 5 vowel phonemes /ei/, /iː/, /ai/, /ou/ and /uː/ in initial and terminal position. These were all the monosyllabic words the author could think of, where the vowel phoneme occurred at either the beginning or the end of the word. All the words used in this count are listed in Appendix C. The most common spellings are shown in Table 5-2.

	(a) Position-sensitive			(b) Position-independent
Phoneme	Initial	Medial	Terminal	
/ei/	a_e	a_e	ay	a_e
/iː/	ea	ea	ee	ea
/ai/	i_e	i_e	y	i_e
/ou/	oa	o_e	ow	o_e
/uː/	oo	oo	ew	oo

TABLE 5-2. Most common spellings in English in (a) position-sensitive count and (b) position-independent count

Also shown in this table are the most common spelling for the phoneme in medial position and the most common position-independent spellings, as listed in Chapter 4. It can be seen that for all five vowel phonemes, the most common spelling when the phoneme occurs in terminal position is different to the most common spelling in medial position. Also, the most common spelling for the phoneme /ou/ in initial position is different to that in medial position. For the rest of the phonemes, the most common spellings in initial and medial position are the same, and are the same as the most common position-independent spelling.

5.2.4.2 Analyzing the data

For each child, 5 graphs were drawn. Each graph corresponded to the spellings for one of the 5 vowel phonemes, /ei/, /iː/, /ai/, /ou/ and /uː/, and contained all the spellings for nonwords containing that vowel phoneme (Figure 5-1). The vertical axis of the graph represented the initial consonant phonemes, and the horizontal axis represented the terminal consonant phonemes of the nonwords. The first row represented an absent initial consonant phoneme, and therefore contained all nonwords which had a VC structure, i.e. where the vowel phoneme occurred in initial position. The first column represented an absent terminal consonant phoneme and therefore contained all the nonwords which had a CV structure, i.e. where the vowel phoneme occurred in terminal position.

	/i:/	**Terminal phoneme**					
		-	/b/	/d/	/f/	...	/z/
	-		eeb		eafe		
	/b/						
	/d/	dey	deab		deaf		dease
Initial	/f/						
phoneme	/g/	gee	geabe	geed	gear		geaze
	.						
	.						
	.						
	/z/	zine	zeab	zead	zeaf		zeas

FIGURE 5-1. Example of a nonword graph for the vowel phoneme /i:/

All the nonword spellings for each vowel phoneme were then plotted on the graph. The graph enabled common spellings in different contexts to be immediately visible. For example, by looking down the first column common spellings for the vowel phoneme in terminal position could be identified. By looking along the row for initial phoneme /z/, common spellings for the vowel phoneme when preceded by that phoneme can be seen.

For each of the 5 vowel phonemes, the most frequently used grapheme was identified for each position of the vowel phoneme: initial, medial and terminal. The frequency with which these graphemes were used was noted as a percentage of all spellings of that phoneme in that position. The graphemes which differed from the most common English spellings in the same position were also noted. Finally, any peculiar spelling which occurred when preceded or followed by a particular consonant phoneme was noted.

5.3 Three case reports

Due to the large amount of data gathered for each child, the phoneme-grapheme mappings of only 3 children - LC, MD and JL - are described below. These are presented in order to demonstrate the different strategies used by individual children. These three were chosen on the basis that they each demonstrated strategies that were commonly used by the other children (such as letter-name spelling - see Chapter 4), but occasionally also demonstrated highly individual strategies.

5.3.1 Case report 1: LC

The graphemes used most frequently by L.C. for each vowel phoneme are shown in Table 5-3. Out of these 15 position-sensitive graphemes, 9 are different to the most common grapheme found in English. LC appears to be fairly confident in her spelling of the medial position phonemes /ei/, /ai/ and /ou/, since the graphemes are each used for at least 75% of occurrences of the phonemes. She appears to be very unsure of the spelling of the phoneme /i:/ in medial position where a variety of graphemes are used. The most frequently used grapheme 'e_e' is only used 45% of the time. Other graphemes which were used more than once are 'e', 'i_e', 'ie_e', 'ea_e', 'ee' and 'ea'. There appears to be no pattern in terms of how each of these graphemes is used in relation to surrounding phonemes.

Phoneme	Position	Grapheme	Freq (%)
/ei/	Initial	a_e	50
	Medial	a_e	84
	Terminal	ay	67
/i:/	Initial	e_e*	50
	Medial	e_e*	45
	Terminal	e*	67
/ai/	Initial	i_e	56
	Medial	i_e	90
	Terminal	iy*	60
/ou/	Initial	o_e*	89
	Medial	o_e	76
	Terminal	o/ooe*	40
/u:/	Initial	o_e*	62
	Medial	o_e*	58
	Terminal	oo*	100

TABLE 5-3. LC's phoneme-grapheme grammar
(*differs from position-sensitive count)

The most frequently used grapheme for the phoneme /u:/ in medial position only accounts for 58% of all occurrences. Other graphemes used in medial position are 'oo', 'o' and 'u_e'. There were 8 nonwords beginning with the consonant phonemes /dʒ/; 7 of these were not spelt with the most frequently used grapheme 'o_e', but with the grapheme 'u_e'. Thus /dʒu:b/ was spelt 'tube', /dʒu:g/ was spelt 'juge', /dʒu:m/ was spelt 'jume', /dʒu:p/ was spelt 'jupe', /dʒu:t/ was spelt 'jute' and /dʒu:v/

was spelt 'juve'. This suggests a context-sensitive mapping for the phoneme /uː/ when it occurs following the consonant phonemes /dʒ/.

LC appears to be sensitive to the position in which a phoneme occurs, since the grapheme most frequently used for a phoneme in terminal position is different to the one used in medial position. All the most frequently used graphemes in medial position are the same as those presented in initial position. This pattern is the same for phoneme-grapheme mappings in real words.

5.3.2 Case report 2: MD

The graphemes most frequently used for each phoneme by MD are shown in Table 5-4.

Phoneme	Position	Grapheme	Freq (%)
/ei/	Initial	a*	67
	Medial	a*	100
	Terminal	ay	67
/iː/	Initial	e*	63
	Medial	e*	87
	Terminal	e*	67
/ai/	Initial	i*	100
	Medial	i*	96
	Terminal	iy*	80
/ou/	Initial	o*	100
	Medial	o*	99
	Terminal	o*	80
/uː/	Initial	o*	62
	Medial	o*	89
	Terminal	o*	100

TABLE 5-4. MD's phoneme-grapheme grammar
(* differs from position-sensitive count)

All but one of the graphemes used by MD were different to those found in English. Furthermore, the most frequently used graphemes were different for medial and terminal position for only 2 out of 5 vowel phonemes. This suggests either that MD is not very sensitive to the position of a phoneme in a nonword, or else is unaware that the position of a phoneme has implications for the way it is spelt.

MD appears to use letter-name spellings for the first four vowel phonemes, spelling /ei/ as 'a', /i:/ as 'e', /ai/ as 'i' and /ou/ as 'o'. The fifth vowel phoneme, /u:/, is spelt 'o'. This pattern of letter-name spelling plus 'o' for /u:/ is identical to that found in the study in Chapter 4.

5.3.3 Case report 3: JL

The most frequently used graphemes for each vowel phoneme are shown in Table 5-5. Seven of JL's phoneme-grapheme mappings differed from the most common spellings in English. These tended to be mostly for the phonemes /ou/ and /u:/. JL appeared to have considerable problems with the phoneme /u:/ as the most frequently used grapheme in medial position 'ou_e' accounted for only 23% of occurrences. Other graphemes used in this position were 'ou', 'oo', 'o_e', 'oo_e' and 'u_e'.

The most frequently used grapheme for the phoneme /ou/ in medial position is 'o_e'. This is the same as the most common English spelling for that position. However, it is only used in 58% of occurrences. Other graphemes used for this phoneme are 'ou', 'ou_e' and 'o'. There does not appear to be pattern by which these alternative graphemes are used in respect of the surrounding phonemes.

Phoneme	Position	Grapheme	Freq (%)
/ei/	Initial	a_e	100
	Medial	a_e	95
	Terminal	aye*	67
/i:/	Initial	ea	43
	Medial	ea	48
	Terminal	ee	50
/ai/	Initial	i_e	78
	Medial	i_e	81
	Terminal	ie*	40
/ou/	Initial	ou_e*	56
	Medial	o_e	58
	Terminal	o*	40
/u:/	Initial	ou_e*	39
	Medial	ou_e*	23
	Terminal	oo/o*	50

TABLE 5-5. JL's phoneme-grapheme grammar
(*differs from position-sensitive count)

5.4 Discussion

This study of vowel phoneme spellings in different contexts has provided the phoneme-grapheme grammars of individual children. A comparison of this grammar with the most common spellings in English enables us to pinpoint those phoneme-grapheme mappings which are inaccurate. The detailed analysis can also show whether or not a child uses different graphemes for a phoneme when it occurs in a different position in a nonword. The use of different graphemes suggests that a child has the elementary phonetic segmentation skills which are thought to be necessary for spelling development (Rohl and

Tunmer, 1988). The pattern of letter-name spellings identifies a strategy which the child appears to be using, and the occurrence of context-sensitive spellings where the selection of a grapheme is affected by the preceding consonant phoneme suggests that some nonwords may be spelt by analogy to real words.

An immediate conclusion to be drawn from the nonword spellings in this study is that the children were sensitive to the position of the vowel phoneme in the nonword and that this affected the grapheme which was chosen. This implies that assessment of an individual's spellings should be compared to position-sensitive counts rather than position-independent counts of English phoneme-grapheme mappings.

A limitation of this study was that most occurrences of a vowel phoneme in initial or terminal position in a monosyllabic structure, result in a real word, e.g. 'aid' and 'day'. Thus there are not very many nonwords in which vowel phonemes occur in initial and terminal positions. This makes it difficult to identify the phoneme-grapheme mappings for this position since there may only be 2 or 3 nonwords to go on and any of these may be spelt in an idiosyncratic manner, rather than drawing on the highest contingency phoneme-grapheme mapping for that position.

The methodology used in this chapter focussed on individual children. The aim was to collect enough nonword spellings for each child to be able to identify the phoneme-grapheme mappings held by that child. This methodology differs considerably from that used in experimental psychology - in traditional experimental psychology, groups of children are compared on their performance on one or more measures. The main advantage of case-study methodology is that it gives us more information about the processing of an individual child than a group study can give us. This kind of information is useful not only from the teacher's point of view, but also in that it may be a strategy which is also being used by other children, which has been overlooked in group studies.

Two other areas of research have also used this methodology. The first is cognitive science and the second is cognitive neuropsychology. In cognitive science, an attempt has been made to identify common errors which children make in arithmetic (Brown and VanLehn, 1980; Young and O'Shea, 1981). Cognitive neuropsychology is a relatively new area of psychology, in which case reports are used to support hypotheses about cognitive processes such as language processing and image processing. Much of this research uses brain damaged patients to show how normal functional pathways can be disrupted. Because no two patients have exactly the same brain damage, the methodology in this area has been to look at an individual's processing of different types of stimuli and in different conditions.

Some researchers have attempted to identify similarities between brain damaged patients with reading and spelling difficulties and children with the same kind of difficulties (Baddeley, Ellis, Miles and Lewis, 1982; Temple, 1984). Accordingly, some research has used the case study methodology of cognitive neuropsychology in the study of children with reading and spelling difficulties (e.g. Funnell, 1990). This methodology has become popular in the study of children's spelling difficulties since 'one criticism of much work on the developmental dyslexias is that it has ignored the inherent heterogeneity of the disorder with respect to the nature of reading skills themselves' (Temple, 1986, p. 80).

Some drawbacks of a methodology which focusses on individuals is that findings can not be generalised to the rest of a population, nor can a model of processing be investigated so thoroughly. In the first case, generalisations can not be made since it is possible that the child is exhibiting idiosyncratic behaviour which is not characteristic of his or her peers. In the second case, the possible idiosyncracy of an individual child's processing cannot provide enough evidence for us to test a hypothesis derived from a model.

Having investigated the nonword spellings of individual children, the rest of this thesis uses the more traditional experimental framework which compares the performance of a group of subjects in different conditions. One aim of this methodology is to isolate a variable or variables which have general effects on a group's performance. The effects of these variables can be used to test a hypothesis derived from a model, if the model is used to describe general performance of a group, without attempting to explain individual differences.

5.5 Conclusions

This study shows how nonword spellings may be used to identify a child's phoneme-grapheme mappings. From this we can identify the mappings which are different to those in English, and notice other patterns in a child's grammar. Some of the mappings in the grammars described here showed sensitivity to the position of a phoneme within a nonword, context-sensitivity, and mappings based on letter-name spellings.

CHAPTER 6

The activation of morphemes in the lexicon

6.1 Introduction

In Chapter 2 it was shown that non-phonetic spelling errors could not be explained by the dual-route model of spelling. They could only be explained in terms of both an impaired lexical route and an impaired non-lexical route. In Chapters 3, 4 and 5 it was noted that some children appeared to use lexical information in their nonword spellings. In this chapter it is proposed that morphemes stored in the lexicon may be used to spell nonwords. Since some morphemes have non-phonetic spellings, this may explain some of the non-phonetic spellings which are made on nonwords. An experiment was carried out to see if a morpheme can be activated by a phoneme. The bound morpheme 's' was used, since it can be pronounced in two ways, and both these pronunciations consist of a single phoneme.

6.1.1 Explaining non-phonetic spellings

One of the nonwords which were spelt non-phonetically was /deid/ (rhymes with 'maid') spelt 'daed'. Segmenting the nonword spelling into its constituent graphemes, the phoneme-grapheme mappings which have been used here are initial /d/ spelt 'd', /ei/ spelt 'ae' and terminal /d/ spelt 'd'. The vowel grapheme 'ae' is considered non-phonetic since the phoneme /ei/ is never spelt with the grapheme 'ae' whether it occurs in terminal position or medial position in real words (see Appendix C for a list of phoneme-grapheme mappings). In medial position, as in the nonword /deid/, it is most commonly spelt 'ai' (as in 'maid') or 'a_e' (as in 'male'). It is commonly supposed that the spelling of nonwords involves (a) segmentation of the nonword into phonemes, and (b) mapping of each phoneme onto a grapheme (Ellis and Young, 1988). Consonant phonemes usually have a one-to-one mapping with graphemes (Barry and Seymour, 1988); thus the phoneme /d/ is most likely to be mapped onto the grapheme 'd'. However, why should a child select a non-phonetic grapheme such as 'ae' for the vowel phoneme /ei/?

It is possible that this can be explained in terms of the way in which the nonword spelling was segmented. The spelling 'daed' could be segmented into three different graphemes: 'd', 'a' and 'ed'. The difference between this and the earlier segmentation is that the letter 'E' is interpreted as part of the terminal consonant grapheme rather than as part of the vowel grapheme. The phoneme /d/ is only spelt 'ed' when it occurs as the past participle morpheme, e.g. in the word 'pulled'. There is no research to suggest that phoneme-grapheme mappings are derived from grammatical inflections rather than word stems; however, we do know that morphemes such as 'ed' are stored in the lexicon (Morton, 1980). This suggests that the morpheme 'ed' may be accessed for the purpose of nonword spelling. Thus there may a use of lexical information in what was previously supposed (Shallice, 1981; Beauvois and Derouesne, 1981) to be a non-lexical process, i.e. nonword spelling. A nonword would still be segmented into phonemes, but rather than each phoneme being mapped onto a grapheme using phoneme-grapheme correspondence rules, a phoneme may activate a morpheme, if that morpheme is often pronounced using the phoneme.

6.1.2 Lexical influences on grapheme selection

There is a small amount of research which shows that the two routes may be used interactively in the spelling of nonwords. Nonwords should strictly be spelt using the non-lexical route, converting each phoneme in the nonword to a grapheme that commonly represents that phoneme in English text. Campbell (1983, 1985) has demonstrated a lexical influence in adults on the graphemes that are chosen to spell a nonword. By saying a real word before a nonword, both of which contain the same target phoneme, she found that the spelling of the phoneme in the real word could determine the grapheme that was chosen to spell that same sound in the nonword. Thus if the word 'train' was heard directly before the rhyming nonword /prein/, the nonword was likely to be spelt 'prain'. On the other hand, if the preceding word was 'crane' the nonword was more likely to be spelt 'prane'. This effect is referred to as 'lexical priming' (as discussed in Section 2.2.4.2), where activation of the graphemes contained in the real word are primed for choice in spelling a particular phoneme when it occurs subsequently in a nonword.

Another phenomenon observed by Campbell in the same studies is that nonwords can be partially spelt using real words. What this means is that if there is a real word embedded within the nonword, the rest of the nonword can be constructed around this word, using phoneme-grapheme conversion rules. This effect is called 'lexical parsing'. Lexical priming and lexical parsing are just two ways in which lexical information have been shown to interact with phoneme-grapheme conversion to spell nonwords.

These experiments show how lexical information can be used to prime the choice of grapheme from the phoneme-grapheme conversion rules. However, the spellings resulting from this interaction are still phonetically accurate. Thus /prein/ may be spelt 'prane' or 'prain', 'a_e' and 'ai' being the two most commonly occurring graphemes for the vowel phoneme /ei/. It is suggested in this chapter that one way in which lexical information could cause non-phonetic errors to occur is by actually supplying the non-phonetic segment. The lexicon is an obvious source of non-phonetic spellings since English words are stored there, and English words are often not spelt phonetically.

The use of lexical information to spell unfamiliar words could occur in the following stages: (1) a word is heard for which no lexical representation can be accessed; (2) the word is segmented into phonemes; (3) these phonemes are mapped onto spellings contained in the lexicon if they exist; and (4) the activated lexical units are used in conjunction with phoneme-grapheme conversion rules to produce a spelling of the target word. The way this would produce a non-phonetic spelling of the target word is if the spelling of a sub-word level unit is itself spelt non-phonetically.

The third stage is of most interest here: that is, on hearing a sub-word level unit is the spelling of a morpheme activated in the lexicon? This chapter presents an experiment that was carried out to test for such activation. Whereas the previous studies had been conducted with children, this experiment is carried out with adults. This is because the previous studies were interested specifically at the spellings of children with spelling difficulties. In this chapter, I was more interested in a general theory of spelling, and therefore decided to use adult subjects.

6.2 Method

A phoneme-classification task was designed to see if hearing a phoneme could activate the spelling of a morpheme in the lexicon. The premise was that if the spelling of the activated morpheme was non-phonetic, this would interfere with, and thus impair, classification of the phoneme.

One morpheme which is pronounced as a single phoneme is the plural noun morpheme 's'[1]. This has two pronunciations: the unvoiced /s/ as in the word 'groups', and the voiced /z/ as in the word 'dreams'. The first pronunciation is phonetic; the second, nonphonetic. Here, the graphemes 's', 'se' and 'ss' are all treated as phonetic transcriptions of the phoneme /s/ because they contain the letter 'S'. A phonetic transcription of the phoneme /z/ would therefore contain the letter 'Z', as in the words 'jazz' and 'sneeze'. This definition of a 'phonetic' spelling is different to those based on frequency counts of phoneme-grapheme correspondences (e.g. Barry and Seymour, 1988). One reason for this is that people are more aware of the relationship between phonemes and letter names than between phonemes and graphemes. This is because a phoneme is not a natural unit of speech (Ladefoged, 1967) but is rather used by phoneticists to define a unit of speech. On the other hand, we

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[1] A single phoneme morpheme was used because it was assumed that, in non-lexical spelling, a nonword would be segmented into individual phonemes and each of these would be converted into a grapheme. If a poly-phonemic morpheme (such as 'ing') had used, we could not assume that the nonword had been segmented into individual phonemes, since the morpheme may be segmented as a single unit.

are all taught how to write the individual letters of the alphabet and we all know their names, even though pronunciation of the letter name may be different from the most common pronunciation of that letter as it occurs in words. This is why children frequently use letter names to spell vowel phonemes (Read, 1986).

According to Morton (1980) the plural noun morpheme 's' is stored in the lexicon along with its two pronunciations, /s/ and /z/. If hearing the phoneme /z/ activates the morpheme 's' in the lexicon, we might expect that identification of this phoneme will be impaired. On the other hand, if there is no activation of the morpheme, there should be no impairment of identification.

6.2.1 Design

The experiment involved presentation of the phonemes /s/ and /z/ at the end of words and rhyming nonwords. There were two types of words: plurals, e.g. 'groups' and 'dreams', where the terminal phoneme represented the plural noun morpheme 's', and non-plurals, e.g. 'case' and 'was', where the terminal phoneme did not represent a grammatical morpheme. If the terminal phoneme activates the morpheme 's' in the plural condition, more errors should be expected in classifying /z/ than /s/ as the former is a non-phonetic pronunciation of the morpheme.

Non-plurals and nonwords were included to control for any orthographic effect. An orthographic effect is the effect that knowing a sound's spelling has on perception of that sound. For example, Seidenberg and Tanenhaus (1979) showed that the perception of rhyming phonemes at the end of words was affected by the orthographic similarity of the words. Thus, 'pie' and 'lie' would be perceived as rhymes more quickly than 'pie' and 'rye'. Similarly, Ehri and Wilce (1980) showed that the phoneme /t/ was more likely to be perceived in the word 'pitch' than the word 'rich', because 'pitch' contains an extra letter.

The orthographic effect occurs independently of any morphemic significance the phoneme might have. Thus in the plural condition, if more errors are made classifying /z/ than /s/, this could simply be due to the phoneme /z/ being spelt non-phonetically in the words, and the phoneme /s/ being spelt phonetically. The difference could not then be attributed to activation of a non-phonetic morpheme. Non-plurals were used since the terminal phoneme in a non-plural does not have any morphemic significance, and nonwords were used since the terminal phoneme in a nonword has neither morphemic significance nor any graphemic representation (its spelling is not known).

Thus there would be two types of information which may impair the perception of the phoneme /z/. These can be called 'orthographic contradiction' and 'morphemic contradiction'. The effect expected for each type of word and nonword ending in /z/ are summarised in Table 6-1.

Stimulus	Example	Spelling of the phoneme /z/	Orthographic contradiction	Morphemic contradiction
PLURAL	dreams	's'	yes	yes
NON-PLURAL	was	's', 'se' or 'ss'	yes	no
NONWORD	/nɔz/	- none -	no	no

TABLE 6-1. Summary of information expected to contradict the phoneme /z/

It can be seen that for plurals ending in /z/ there are two types of information contradicting the phoneme, one type of information contradicting the phoneme in non-plurals, and no contradiction in the nonwords. The morphemic contradiction expected for plurals is due to the activation of the morpheme 's' by the phoneme. For comparison, Table 6-2 shows that there is no expected contradiction between the phoneme /s/ and the two types of information.

Stimulus	Example	Spelling of the phoneme /z/	Orthographic contradiction	Morphemic contradiction
PLURAL	groups	's'	no	no
NON-PLURAL	dress	's', 'se' or 'ss'	no	no
NONWORD	/gres/	- none -	no	no

TABLE 6-2. Summary of information expected to contradict the phoneme /s/

Three main hypotheses are derived from these tables. The hypotheses are based on the notion that each type of contradiction is cumulative; that is to say, the more contradiction a phoneme encounters, the more errors will be made perceiving it. Thus, more errors are expected on phonemes presented in words encountering both types of contradiction than on words encountering only one type of contradiction, and more errors are expected on phonemes encountering one type of contradiction than on phonemes encountering no contradiction. The three main hypotheses and three control hypotheses are listed below.

Hypothesis 1: the orthographic effect (I)

(a) Within the non-plural words, more errors will be made on those ending in /z/ than on those ending in /s/, e.g. 'was' > 'case'. This is because the orthographic image of the words with both endings will be activated, and the letter ‘S’ will be ‘seen’; thus the subjects will be more likely to think that the word ends in the phoneme /s/.

(b) CONTROL: Within the nonwords which rhyme with the non-plurals, there will be no difference between the number of errors made on those ending in /z/ and those ending in /s/, e.g. /nɔz/ <> /neis/.

Hypothesis 2: the orthographic effect (II)

(a) More errors will be made on non-plurals ending in /z/ than on the rhyming nonwords, e.g. 'was' > /nɔz/. This is because an orthographic image will be activated for the non-plural as it is a real word, and the spelling of the terminal phoneme will be ‘seen’. For the nonword, no such orthographic image is available.

(b) CONTROL: There will be no difference between the number of errors made on non-plurals ending in /s/ and the rhyming nonwords, e.g. 'case' <> /neis/.

Hypothesis 3: the effect of activating the 's' morpheme

(a) Within the group of real words ending in /z/, more errors will be made on plurals than on non-plurals, e.g. 'dreams' > 'was'. This is because orthographic images will be activated for both words, but in addition to this, the plural noun morpheme ‘s’ will be activated for the plural word.

(b) CONTROL: Within the nonwords ending in /z/, there will be no difference between those rhyming with plurals and those rhyming with non-plurals, e.g. /friːmz/ <> /nɔz/.

6.2.2 Subjects

Forty-six Open University undergraduates volunteered to participate in the experiment. They were attending the D309 (Cognitive Psychology) Summer School at the University of Sussex.

6.2.3 Materials

Two sets of stimuli were used: real words ending in the phonemes /s/ and /z/, and rhyming nonwords ending in the same phonemes.

6.2.3.1 Real word stimuli

The first set of stimuli consisted of 56 real words. Half of these were plurals and half were non-plurals.

PLURALS. The subset of plural words was constructed as follows: 28 regular nouns were chosen from the Thorndike-Lorge list of frequently occurring words (Thorndike and Lorge, 1944). These were single nouns which could be made into a plural by adding the letter 'S', e.g. 'group', 'dream'. When made into the plural form, half the nouns ended in the unvoiced phoneme /s/, e.g. 'groups'; the other half ended in the voiced phoneme /z/, e.g. 'dreams'. No nouns were selected if, when the alternative phoneme was added to the stem, it made another word. For example, the terminal phoneme of the plural 'knees' is /z/. If the phoneme /s/ is substituted for /z/, this makes the word 'niece'; thus the single noun 'knee' would not be included. The plural forms of the nouns were used in the experiment. These are shown in Table 6-3.

/s/		/z/	
Word	**Nonword**	**Word**	**Nonword**
accounts	/daunts/	answers	/ˈplaːnsəz/
banks	/læŋks/	boys	/fɔiz/
books	/wuks/	days	/teiz/
cakes	/veiks/	doctors	/ˈbrɔktəz/
facts	/dækts/	dreams	/griːmz/
groups	/kruːps/	evenings	/niŋz/
hearts	/laːts/	girls	/də·lz/
lights	/paits/	legs	/fegz/
moments	/ploumənts/	miles	/kailz/
nights	/vaits/	schools	/fruːlz/
objects	/dʒekts/	shoulders	/ˈgrouldəz/
ships	/fips/	trees	/priːz/
streets	/priːts/	wheels	/biːlz/
weights	/dʒeits/	windows	/dʒouz/

TABLE 6-3. Plurals and rhyming nonword stimuli

NON-PLURALS. The subset of 28 non-plurals was constructed as follows: words ending in the graphemes 's', 'se' or 'ss' were selected from the Thorndike-Lorge list of high frequency words; these could be single nouns or non-nouns. Half the words ended with the phoneme /s/, e.g. 'case', and the other half with the phoneme /z/, e.g. 'was'. A word was not included if, on substituting one terminal phoneme for the other, another real word was made. For example, substituting /s/ for /z/ in the word 'phase' we get the word 'face'; substituting /z/ for /s/ in the word 'cease' we get the word 'seize' or 'seas'. Words which were homophones, such as 'pause' and 'paws', were also excluded.

The 28 plurals and 28 non-plurals were combined into a list which was ordered randomly. The terminal phoneme of each word was removed, leaving the 'stem' of the word. This is not the stem of the word in any grammatical sense, although for the plural words this happened to be the case; rather, it is used here to denote the remainder of the word once the terminal phoneme has been removed. The words were to be presented without the terminal phoneme in order to prevent against the experimenter stressing the voiced or unvoiced nature of the terminal phoneme during verbal presentation of the stimuli, and possibly biasing the subject's perception of that phoneme. So, for example, the word 'girls' was reduced to 'girl', and the word 'has' was reduced to the phoneme string /hæ/. The set of non-plurals is shown in Table 6-4.

/s/		/z/	
Word	**Nonword**	**Word**	**Nonword**
across	/prɔs/	always	/neiz/
bless	/gres/	because	/nɔz/
case	/neis/	does	/wʌz/
Christmas	/wʌs/	has	/fæz/
dress	/fles/	is	/niz/
famous	/ˈkreiməs/	noise	/hɔiz/
grass	/traːs/	please	/kliːz/
increase	/kliːs/	suppose	/kouz/
kiss	/bis/	surprise	/klaiz/
loss	/nɔs/	these	/giːz/
perhaps	/hæps/	those	/trouz/
purpose	/ˈkləːpəs/	was	/hɔz/
this	/bis/	whose	/fuːz/
yes	/fes/	wise	/faiz/

TABLE 6-4. Non-plurals and rhyming nonword stimuli

6.2.3.2 Nonword stimuli

The second set of stimuli consisted of 56 nonwords rhyming with the real words. In constructing the nonwords a number of considerations were taken into account so that, as far as possible, the phonetic structure of the rhyming real word was retained. Where a phonetic consonant cluster occurred in the real word, a consonant cluster of similar complexity was used in the nonword. For example, both the real word 'bless' and the nonword /gres/ begin with two consonant phonemes. Where there were two syllables in the real word and the stress was on the first syllable, e.g. 'promise', a two syllable nonword was made so that both syllables of the nonword rhymed with those of the real word, e.g. 'promise' was rhymed with /ˈklɔmis/. If the stress in a two-syllable word was on the second syllable, e.g. 'perhaps', this syllable was used if it was a nonword, e.g. 'perhaps' was rhymed with /hæps/. If the second syllable happened to be another word, a rhyme was made with the second syllable. For example, the second syllable of 'accounts' is 'counts', so this was rhymed with /dau:nts/.

A nonword was not included if, when one of the terminal phonemes /s/ and /z/ was substituted for the other, a real word was made. For example, 'kiss' rhymes with the nonword /fis/, but substitution of /z/ for /s/ in this nonword gives the real word 'fizz', so another nonword was found.

The nonwords were ordered into a list, the position of each corresponding to the position of the rhyming real word in the other list. The terminal phonemes were not removed since the subject would not know which phoneme to add, given that neither the addition of /s/ nor the addition of /z/ would produce a real word.

The nonwords rhyming with the plurals are shown in Table 6-3 and the nonwords rhyming with the non-plurals are shown in Table 6-4.

6.2.4 Procedure

Each subject was seen individually. They were told that the experimenter was looking at how people perceive sounds, in particular 'S-sounds' (the phoneme /s/) and 'Z-sounds' (the phoneme /z/). The experimenter explained that S-sounds were those at the end of such words as 'nervous', 'mouse', and 'gas', and that 'Z-sounds' were those at the end of such words as 'suppose', 'arouse' and 'revise'. It was explained that S-sounds also occurred at the end of plural words such as 'dates', 'grapes' and 'clocks', and that Z-sounds also occurred at the end of such plural words as 'mornings', 'apples' and 'mountains'.

An informal trial was carried out to establish that the subject could distinguish between the two phonemes: the experimenter picked one word at a time from the above examples and said it aloud stressing the terminal phoneme. The subject repeated the whole word and then said which of the two sounds occurred at the end of the word. This continued until they felt fairly confident and most categorizations were correct.

The real word stimuli were presented first. The subject's task was to indicate on a response sheet (see Appendix E) which of the two sounds should be added to each word 'stem' in order to make another word. This was done by circling an 's' or a 'z' respectively for each stimulus. The experimenter spoke each stimulus aloud and the subject repeated it to show they had heard it correctly. Subjects were asked to perform the task as quickly as possible, circling the first response that came into their heads.

The nonword stimuli were presented second. Each nonword was spoken aloud by the experimenter and repeated by the subject who then categorised the terminal phoneme on a response sheet as for the real words. Again, subjects were asked to perform the task as quickly as possible.

Each subject's response to each stimulus was scored as right or wrong, and the number of errors totalled for plurals ending in /s/, plurals ending in /z/, non-plurals ending in /s/ and non-plurals ending in /z/, and for each of the corresponding groups of nonwords. The final error score for each group of stimuli was out of 14 and was converted to a percentage error rate. The average error rate for each stimulus group was then taken across all 46 subjects.

6.3 Results

The mean error rates (as percentages) for real words are shown in Table 6-5, and the mean error rates for nonwords are shown in Table 6-6. In each table, the percentage represents the number of errors made out of 14 stimuli.

Non-plurals		Plurals	
/s/	/z/	/s/	/z/
e.g. 'case'	e.g. 'was'	e.g. 'groups'	e.g. 'dreams'
5.5 (12.6)	13.3 (15.5)	7.2 (11.3)	31.0 (27.9)

TABLE 6-5. Mean percentage of errors made on real words

Two-way ANOVAs and paired t-tests were carried out on the data[2]. The independent variables used for the ANOVAs were 'terminal phoneme' (two levels: terminal phoneme /s/ and terminal phoneme /z/) and 'grammatical status' (two levels: plural and non-plural). For the nonwords, the 'grammatical status' levels were 'plural rhymes' and 'non-plural rhymes', since there is no such thing as a 'plural' or 'non-plural' nonword. ANOVAs could not be used to make direct comparisons between the real words and nonwords since the variable 'grammatical status' was meaningless for the nonwords.

Non-plural rhymes		Plural rhymes	
/s/	/z/	/s/	/z/
e.g. /neis/	e.g /nɔz/	e.g /kru:ps/	e.g /fri:mz/
5.9 (11.4)	7.0 (14.7)	13.2 (16.2)	20.4 (20.8)

TABLE 6-6. Mean percentage of errors made on nonwords

The tests on the data showed the following:

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2 Given that some of the standard deviations in the data appeared quite large, an arcsin transformation was carried out prior to the ANOVA tests in order to stabilise the variance (see Winer, 1971, p. 400). The data were not tested for homogeneity of variance since 'a test of homogeneity of variance before the analysis of variance has rather limited practical utility, and modern opinion holds that the analysis of variance can and should be carried on without a preliminary test of variances, especially in situations where the number of cases in the various samples can be made equal' (Hays, 1969, p. 381). Fortunately, the sample sizes in this experiment were indeed equal.

(i) within the non-plural words, more errors were made on those ending in /z/ than on those ending in /s/, e.g. 'was' > 'case' ($F(1,45)=13.5$, $p<0.01$). This confirmed Hypothesis 1(a);

(ii) within the nonwords which rhymed with the non-plurals, there was no significant difference between the number of errors made on those ending in /z/ and those ending in /s/, e.g. /nɔz/ <> /neis/ ($F(1,45)=0.5$, n.s.). This confirmed Hypothesis 1(b);

(iii) more errors were made on non-plurals ending in /z/ than on the rhyming nonwords, e.g. 'was' > /nɔz/ ($t=2.840$, $df=45$, $p_{1\text{-}tail}<0.005$). This confirmed Hypothesis 2(a);

(iv) there was no significant difference between the number of errors made on non-plurals ending in /s/ and the rhyming nonwords, e.g. 'case' <> /neis/ ($t=0.660$, $df=45$, n.s.), i.e. Hypothesis 2(b) was confirmed;

(v) within the group of real words ending in /z/, more errors were made on plurals than on non-plurals, e.g. 'dreams' > 'was' ($F(1,45)=34.3$, $p<0.001$), i.e. Hypothesis 3(a) was confirmed; and

(vi) within the nonwords ending in /z/, more errors were made on those rhyming with plurals than on those rhyming with non-plurals, e.g. /friːmz/ > /nɔz/ ($F(1,45)=31.3$, $p<0.001$), i.e. Hypothesis 3(b) was not confirmed.

Thus the first five hypotheses were confirmed, but the sixth was not. In addition to this unexpected difference, there were other unexpected differences in the errors made within the group of nonwords. As well as the difference for those ending in /z/ reported as result (vi) above, the error rate for those ending in /s/ was significantly higher for plural rhymes than for non-plural rhymes, e.g. /kruːps/ > /neis/ ($F(1,45)=17.5$,

$p<0.001$). Also, as with the real words, significantly more errors were made on nonwords ending in /z/ than on nonwords ending in /s/, e.g. /fri:mz/ > /kru:ps/ ($F(1,45)=5.3$, $p<0.05$).

6.4 Discussion

The results of the phoneme classification task provide evidence both for the orthographic effect and for activation of a sub-word level morpheme in the lexicon via phonemic input. The orthographic effect occurs when we hear a phoneme whose spelling we know (Seidenberg and Tanenhaus, 1979; Ehri and Wilce, 1980). This was demonstrated by impaired perception of the phoneme /z/ when it was spelt with a grapheme containing the letter 'S', e.g. 'was' and 'noise'. On hearing (or saying) a word, the orthographic image of the word is activated, i.e. we can 'see' that the word contains the letter 'S' near the end, and this contradicts our expectation of what the terminal phoneme should be.

The morphemic effect may occur for a similar reason, except that on hearing the phoneme in the context of a plural word we activate the individual morpheme 's' as well as an orthographic image. Thus, in working out whether the phoneme at the end of 'was' is /s/ or /z/, we wrongly expect it to be /s/ because it is spelt with the letter 'S'. One subject reported experiencing something 'like a Stroop effect' with the word 'has' where she reported hearing a Z-sound although she could see it was spelt 's'. In trying to identify the phoneme /z/ at the end of 'dreams' we have both the knowledge that it is spelt with the letter 'S', and knowledge that it is a plural, plurals typically ending in the letter 'S'. It is the latter knowledge that activates the morpheme 's' in the lexicon.

In this experiment, there was an unexpected increase in errors made on nonwords rhyming with plurals. Ideally this should not have occurred since nonwords should not be associated with either orthographic images or syntactic categories. However, one explanation for errors made on those ending in /z/ could be that 3 out of the 14 plural nonwords had two syllables and sounded so much like the rhyming real words that some subjects remembered the real word, indirectly activating the plural noun morpheme for the real word. This was the case for at least one subject who reported remembering the word 'doctors' on hearing the nonword /ˈbrɔktəz/. In addition to this, 6 of the remaining monosyllabic nonwords ended in consonant clusters, e.g. /fegz/, which may have made the terminal phoneme more difficult to identify. By comparison, all the non-plural rhymes ending in /z/ were monosyllabic and the terminal phoneme in each case was preceded by a vowel phoneme. This would explain why Hypothesis 3(b) failed to be confirmed, where no difference was expected between plural and non-plural rhymes ending in /z/.

The increase in errors on the plural rhymes ending in /s/ cannot be accounted for by association with the rhyming real words since the real words ended in /s/, so any activation of the plural noun morpheme would not have produced impairment because of a non-phonetic pronunciation. However, as with the nonwords ending in /z/, all the plural rhymes ended in consonant clusters, e.g. /dækts/, /fips/. In the non-plural rhymes ending in /s/, only one nonword (/hæps/) ended with a consonant cluster. Subjects appeared to be unaware that the voiced or unvoiced nature of the preceding phoneme determined whether or not the terminal phoneme was /s/ or /z/. The difficulty in discerning a terminal consonant phoneme within a consonant cluster would cause less problems when it occurs at the end of a real word because there is other information that can be used.

It is possible that during the experiment, two separate processes were employed for plurals and non-plurals, even though the end process for both involves classifying the terminal phoneme. In the case of plural words, the 'stem' consisted of a real word. Because of the automatic way in which orthographic representations seem to be generated, the orthographic representation of this word would be accessed. Since we know a single noun can be extended by adding the letter 'S', this may be what happens during the task. The subject, rather than adding a phoneme and then categorising that phoneme, adds the letter 'S'. They then have to identify whether this letter is pronounced /s/ or /z/.

On the other hand, the non-plural 'stems' were not complete words and so the orthographic representation of the stem would not be immediately accessed. The target word may be more easily constructed by adding a sound and seeing which is the right one. Whichever process was used to generate the plural and non-plural target words, a decision has to be made about the terminal phoneme of each stimulus. In a task where responses are scored as right or wrong, the use of different processes should not affect the data. However, if the experiment was repeated using reaction times, we should expect the plurals to take more time since the orthographic image of the stem is accessed as well as that of the plural form.

It was suggested earlier that using a morpheme when spelling part of an unknown word or nonword may result in a non-phonetic spelling of that word if the spelling of the morpheme is non-phonetic. The results of this experiment provide evidence that, in adults, sub-word level morphemes in the lexicon can be activated via their phonological representations.

6.5 Conclusions

This chapter has described an experiment in which adults classified phonemes at the end of words and nonwords. The experiment showed that the phoneme /z/ can activate the plural noun morpheme 's' when a plural is expected from the context. The activation of a morpheme by a phoneme means that, when a nonword is segmented into phonemes during spelling, one of these phonemes may activate a morpheme which may be used in the nonword. The next chapter describes an experiment which investigates whether or not morphemes can be primed for use in nonword spelling.

CHAPTER 7

The use of morphemes in nonword spelling

7.1 Introduction

In Chapter 6, it was proposed that nonwords could be spelt using morphemes stored in the lexicon. If these morphemes were non-phonetic, this may account for the non-phonetic spelling of a nonword. It was thought that nonwords would be spelt as follows: first, the nonword is segmented into individual phonemes. Secondly, if one of the phonemes is a pronunciation of a morpheme in the lexicon, the morpheme may be activated by the phoneme and used to spell that phoneme in the nonword. This activation of a morpheme by a phoneme was investigated in Chapter 6 using a phoneme classification task. It was found that the phoneme /z/ could activate the plural noun morpheme 's', even though this is a non-phonetic spelling of the phoneme.

It is proposed that if a sound is spelt when it occurs within the context of a nonword, there are two types of spelling which may compete for selection. The first is the phonetic spelling, i.e. that found in most non-morphemic occurrences of the sound, and the second is the morphemic spelling, found in morphemic occurrences of the sound. Where there is more competition from the phonetic spellings, the morphemic spelling may be less likely to be selected, and vice versa. The experiment described in this chapter examines the effect of competition from phonetic spellings on the use of a morpheme in nonword spelling.

7.1.1 English usage of the morpheme 'ed'

The experiment in Chapter 6 investigated the activation of the plural noun morpheme 's'. The experiment in this chapter investigates the use of another morpheme which has non-phonetic pronunciations: the past participle morpheme 'ed'. There are three ways in which this morpheme can be pronounced: /d/, /t/ and /əd/ (or /id/). Each pronunciation is dependent on the pronunciation of the phoneme which occurs before the morpheme, i.e. the phoneme at the end of the verb stem. The rules for pronunciation of the morpheme are:

(1) /əd/ (or /id/) after stems which end in /t/ or /d/, e.g. 'melted', 'mended';

(2) /t/ after stems which end in the phonemes /f/ /k/ /p/ /ʃ/, e.g. 'laughed', 'packed', 'stopped', 'wished'; and

(3) /d/ after all other stem endings, i.e. the voiced consonants /b g ð l m n ŋ v ʒ/, e.g. 'robbed', 'hugged', 'bathed', 'sailed', 'aimed', 'rained', 'banged', 'loved' and 'raged', and the vowels /ei iː ai ou uː ε ɔː au əː/, e.g. 'played', 'agreed', 'died', 'showed', 'stewed', 'cared', 'poured', 'allowed', 'purred'.

These pronunciations are not rules which have to be learnt; rather, they arise from the physical constraints of articulating voiced and unvoiced phonemes one after the other. The impossibility of articulating two stop consonants (e.g. /d/ and /d/, /d/ and /t/, /t/ and /t/, /t/ and /d/) without a vowel phoneme between them means that a vowel phoneme, usually /ə/, has to be used to separate them. This means that the first pronunciation, /əd/, is a syllable in itself. As a result, all past participles with this ending have at least two syllables, i.e. the number of syllables in the stem plus one extra one. For example, 'heat' has one syllable, but 'heated' has two syllables.

The phonemes /d/ and /t/ are both 'stop' consonants, the only difference between them being that /d/ is voiced and /t/ is unvoiced. The voicing of a stop consonant depends on whether or not the preceding phoneme is voiced. Since these phonemes are simply attached to the preceding stem, past participles ending in these phonemes have the same number of syllables as the stem form. For example, 'move' and 'moved' both have one syllable, as do 'pack' and 'packed'.

7.1.2 Phonetic spellings of /d/, /t/ and /əd/

The grapheme 'ed' is here treated as a 'non-phonetic' spelling of the sounds /d/, /t/ and /əd/ because they only have this spelling when they are representing the morpheme. Thus, this grapheme has primarily syntactic significance, rather than phonetic significance (Albrow, 1972; Baker, 1980). In all other occurrences, i.e. non-morphemic occurrences, the three sounds have a different spelling. Thus the 'phonetic' spelling of these sounds is interpreted as the most common non-morphemic spelling in English. The letters ‘ed’, when they occur non-morphemically, are usually pronounced /ed/, as in ‘bed’.

The syllable /əd/ occurs only at the end of Latin derived adjectives such as 'rapid', 'humid' and 'rigid' and is always spelt 'id'. In past participles, this syllable only occurs after the phonemes /d/ and /t/. Thus 'id' is presumed to be a phonetic spelling for this syllable when it occurs at the end of a word.

When the sound /d/ occurs at the end of a word it is usually spelt 'd', as in 'hand', 'mad', 'hold' and 'wood'. The phonetic spelling of /d/, then, is taken as 'd' when it occurs at the end of a word.

The sound /t/ at the end of a word is usually spelt 't', for example in 'beat', 'hunt', 'mast' and 'foot'. The phonetic spelling for this at the end of a word is therefore taken as 't'.

No actual counts of token frequencies for spellings of these three sounds could be found in the literature. These phonetic spellings are context-sensitive in that they are taken from the occurrence of the sounds at the end of a word only, and not in any other position, whether or not an analysis of the sounds in another position would have the same spellings.

7.1.3 Non-morphemic frequency

It is proposed that when a sound is spelt within a nonword, the morpheme which can be pronounced as that sound competes against the phonetic spellings of the sound found in non-morphemic occurrences within real words. The competition can be measured in terms of the number of words in which the sound occurs, when the sound is not representing the morpheme. Since this measurement is in terms of how many words there are, rather than the frequency of occurrence of these words in text, this is a count of 'type' frequency. It was expected that those sounds for which non-morphemic frequency is highest will be less often spelt using the morpheme, than those sounds for which non-morphemic frequency is low.

To calculate non-morphemic frequency of the three sounds, a count was taken of the number of words which ended in each sound, based on all such words known to the author. Because these sounds only occur as the past participle morpheme 'ed' when preceded by certain phonemes, the count was of non-morphemic occurrences of the three sounds when they are preceded by these phonemes. The preceding phonemes used in the count, and the frequency of words in each group, are shown in Table 7-1. The words included in the count are given in Appendix F.

End sound	Preceding phoneme	Non-morphemic frequency	Example
/d/	/l/	20	cold
	/n/	51	band
	/ei/	13	maid
	/ai/	9	pride
	/ɔː/	8	board
	/uː/	6	brood
	/ou/	5	road
	/əː/	4	bird
	/au/	4	cloud
	/aː/	3	card
	/ɔi/	1	void
	TOTAL	124	
/t/	/k/	5	fact
	/f/	22	lift
	/p/	9	crypt
	/s/	65	best
	TOTAL	101	
/əd/	/d/	3	sordid
	/t/	1	fœtid
	TOTAL	4	

TABLE 7-1. Non-morphemic frequency for pronunciations of the morpheme 'ed'

This frequency count shows that, of the three pronunciations of the morpheme 'ed', /d/ has the highest non-morphemic frequency (124 words) followed by /t/ (101 words) and then /əd/ (4 words). It is therefore expected that nonwords ending in the sound /d/ will provide more non-morphemic competition than nonwords ending in the sounds /t/ and /əd/.

7.2 Method

7.2.1 Design

The two variables in the experiment were presentation context and nonword ending. Stimulus nonwords were presented in three different contexts: context-free, verb context and noun context. There were three nonword endings: /d/, /t/ and /əd/. The ending /d/ had highest non-morphemic frequency, followed by the endings /t/ and /əd/. It was expected that more nonword endings would be spelt morphemically when presented in the verb context than when presented in the noun context or context-free. In these two conditions, the use of the morphemic ending was expected to be equal, since it would be based on a default level of activation of the morpheme. It was also expected that the nonword ending with the lowest non-morphemic frequency, i.e. /əd/, would be spelt morphemically more often than the other nonword endings.

7.2.2 Subjects

Thirteen research students and research fellows (8 male and 5 female) took part in the experiment. They were all based at the Open University.

7.2.3 Materials

Thirty nonwords were constructed, 10 ending in each of the sounds /d/ /t/ and /əd/. These were ordered in three lists: one for context-free presentation, and the other two for mixed verb and noun presentation.

7.2.3.1 The nonword stimuli

All nonwords with /d/ and /t/ endings were monosyllabic; nonwords ending in /əd/ had two syllables. All nonword endings followed a single consonant phoneme. For example, in the nonword /sɔnd/, the sound /d/ follows the phoneme /n/. This was to enable unambiguous coding of the data. For example, where a stimulus nonword was spelt ending in the letters 'ed' (e.g. 'sonned'), and these letters followed consonant graphemes ('nn'), it could be assumed that the letters 'ed' represented a morphemic spelling. On the other hand, if the nonword ending followed a vowel phoneme (e.g. /tɔːd/ - rhymes with 'board' - where /d/ follows the vowel /ɔː/) and the nonword spelling ended in the letters 'ed' (e.g. 'tored'), the letter 'e' could not safely be said to be part of the morpheme 'ed' since it could have been used to spell the vowel phoneme /ɔː/, as it is in the word 'more'. The nonword ending /d/ may therefore have been spelt non-morphemically, as 'd'. Additionally, the letter 'e' may have been a part of both the vowel grapheme and the nonword ending. To reduce this ambiguity in the data, therefore, all nonword endings followed consonant phonemes.

A second reason for using consonant phonemes to precede the nonword endings was that for verbs ending in a vowel phoneme, e.g. 'say', past participles can have irregular spellings which do not contain the morpheme 'ed', e.g. 'said'. Other examples are 'go' - 'been', 'do' - 'done' and 'fly' - 'flown'. It was thought that selection of a spelling for a nonword ending may be biased against the morpheme 'ed' for 'stems' ending in a vowel phoneme. Thus the nonword 'stems' all ended in consonant phonemes to ensure activation of the 'ed' morpheme.

The consonant phoneme preceding each nonword ending was one for which there are real words ending in the same phoneme sequence, and where the phoneme sequence occurs with both morphemic and non-morphemic spellings. For example, the sound /d/ at the end of a past participle can be preceded by /n/ as in 'gained', or by /m/ as in 'aimed'. The cluster /nd/ also occurs at the end of non-past participles such as 'hand', so the sound /d/ when it occurs after /n/ can be spelt either 'ed' or 'd'. The cluster /md/ only occurs at the end of past participles and not at the end of other words. Because of this, the sound /d/ when it occurs after /m/ is always spelt 'ed'. The nonwords in this experiment ended only in consonant clusters which had both morphemic and non-morphemic spellings in real words. The phonemes preceding each nonword ending are shown in Table 7-2.

Nonword ending	Preceding phoneme	Non-morphemic example	Morphemic example	Nonword example
/d/	/l/	weld	smelled	/keld/
	/n/	hand	banned	/gand/
/t/	/k/	fact	packed	/vækt/
	/p/	crypt	slipped	/gipt/
/əd/	/d/	splendid	mended	/kedəd/
	/t/	fœtid	bleated	/diːtəd/

TABLE 7-2. Phonemes preceding the nonword endings

The first constraint described above was implemented because of the ambiguity which may arise in coding the spelling of a nonword ending, when that ending followed a vowel phoneme. This was because the letter 'e' could be part of the vowel grapheme. However, even when the preceding phoneme is a consonant, the spelling of the vowel preceding *that* may still cause ambiguity. This is because some vowels can be spelt with 'split digraphs', i.e. two letters which surround the following consonant grapheme, and where the second letter in the digraphs is 'e'. In past participles where the verb stem contains such a digraph, the letter 'e' serves two purposes: it is part of the vowel grapheme and it is also part of the morpheme 'ed'. The four graphemes are 'a_e', 'i_e', 'o_e' and 'u_e'. Some of these graphemes can be used to represent more than one vowel phoneme. Table 7-3 shows examples of verb stems and past participles in which these vowel graphemes are used, and also shows the vowel phonemes which can be spelt using these graphemes. These vowel phonemes, /ei/, /ai/, /ou/, /uː/, /ɛ/ and /ɔː/, were therefore excluded from the nonword 'stems' to reduce the possibility of subjects using the split graphemes in the task.

Grapheme	Phoneme	Verb stem	Past participle
a_e	/ei/	rate	rated
	/ɛ/	care	cared
i_e	/ai/	fine	fined
o_e	/ou/	hope	hoped
	/ɔː/	bore	bored
u_e	/uː/	prune	pruned

TABLE 7-3. Examples of words containing split digraphs

A nonword was not included in the stimulus list if a phonetic spelling of the nonword, using high contingency phoneme-grapheme mappings, was likely to produce a real word. For example, the nonword /blind/ (rhymes with 'sinned') may be spelt phonetically as 'blind'. This reads as a real word, but with a different pronunciation to that of the stimulus nonword. It was thought that on seeing this, a subject may want to change their spelling to distinguish it from the real word. Thus to avoid this possibility, nonwords were only included when their phonetic spelling did not make a real word.

Another constraint was that the 'stem' of nonwords ending in /əd/ should not be real words themselves. For example, the first part of the nonword /wend/ (rhymes with 'bend') could be processed as the word 'when'. This sort of nonword was not included just in case the processing of a real word interfered with the task.

The set of 30 nonword stimuli is listed in Table 7-4 which also shows the structure of the nonwords.

Ending	Preceding phoneme	Nonword stimuli
/d/	/l/	reld keld leld
	/n/	sɔnd gænd lɔnd nend vɔnd lʌnd gend
/t/	/k/	gækt tekt mekt vækt dækt
	/p/	gʌpt fæpt gipt fipt dʌpt
/əd/	/d/	mɔːtəd diːtəd fɔtəd lætəd riːtəd
	/t/	kedəd rædəd medəd tiːdəd gedəd

TABLE 7-4. The nonword stimuli

7.2.3.2 The stimulus lists

The nonwords were ordered into three stimulus lists. The first list consisted of the nonwords in random order - this was to be used for the context-free presentations. The second list contained half the nonwords presented as verbs, and the other half presented as nouns. The third list contained the nonwords in the alternative context to that in which they had been presented in the second list. Thus, those nonwords presented as nouns in the second list were presented as verbs, and vice versa.

In the second and third lists, the nonwords were given a 'context' by embedding them in a template sentence. The template sentence used with each nonword was:

'The monkey played with the stick'.

For the verb context, a nonword was substituted for the words *'played with'* in the verb condition, e.g. 'The monkey /gænd/ the stick'. For the noun context, a nonword was substituted for the word *'stick'*, e.g. 'The monkey played with the /gænd/'. For the second list, 15 noun templates and 15 verb templates were ordered randomly and the nonwords from the first list were slotted into them. The nonwords in the third list were presented in the same order as in the second list, but in the alternative context. For example, if /gænd/ occurred as a noun in the second list it would occur as a verb in the third list.

7.2.4 Procedure

Subjects were seen individually and the three stimulus lists were presented in the same sitting. Subjects were told that they were going to be asked to spell some nonwords and that they should write them so that they could be read back accurately at the end of the experiment. For the first list, each nonword was spoken aloud by the experimenter and repeated by the subject. The subject wrote down on lined paper how they thought it might be spelt and then covered it, moving onto the next line down.

The second and third list were presented in the same way as the first except that the whole sentence was read out by the experimenter. The subject had to repeat only the nonword. Each nonword was therefore presented a total of three times: context-free, as a noun and as a verb.

Subjects' spellings were scored in terms of the number of nonword endings spelt 'ed'. Where a nonword ending was spelt like this it was assumed that the spelling represented the past participle morpheme 'ed' (for reasons given in Section 7.2.3.1). Data were scored separately for each nonword ending and each presentation condition.

7.3 Results

The mean scores across the 13 subjects are shown in Table 7-5. These scores, representing the number of nonword endings spelt 'ed', are out of 10. Most of the nonword endings which were not spelt 'ed' were spelt phonetically, i.e. with the endings described in Section 7.1.2. The mean number of nonword endings in each group spelt phonetically are shown in Table 7-6.

As expected, the number of endings spelt 'ed' increased with more nonword endings spelt 'ed' when presented in the verb condition than when presented as a noun or context free. Unexpectedly, more 'ed' spellings occurred in the context-free condition than in the noun context.

		CONTEXT			
		Free (n=10)	**Verb** (n=10)	**Noun** (n=10)	**Total** (n=30)
	/d/	3.0 (2.3)	6.5 (3.4)	1.0 (1.3)	10.5 (5.2)
ENDING	/t/	3.5 (3.3)	7.2 (4.3)	1.9 (3.1)	12.6 (8.8)
	/əd/	7.2 (3.8)	8.9 (1.8)	5.4 (4.6)	21.5 (9.5)
	Total	13.7 (7.6)	22.6 (8.3)	8.3 (7.9)	

TABLE 7-5. Mean number of nonword endings (out of 10) spelt 'ed' (standard deviations in brackets)

		CONTEXT			
		Free (n=10)	**Verb** (n=10)	**Noun** (n=10)	**Total** (n=30)
	/d/	6.1 (2.5)	3.0 (3.2)	8.2 (2.2)	17.2 (6.1)
ENDING	/t/	5.8 (3.6)	2.0 (3.7)	7.4 (3.6)	15.2 (19.0)
	/əd/	2.3 (3.5)	0.7 (1.4)	3.8 (4.3)	6.8 (8.6)
	Total	14.2 (7.4)	5.7 (7.0)	19.3 (8.8)	

TABLE 7-6. Mean number of nonword endings (out of 10) spelt phonetically (standard deviations in brackets)

Due to the standard deviations in some cases being larger than the mean scores, an arcsin transformation was carried out on the data to stabilise the variance prior to analysis (see Winer, 1971, p. 400). A 3 x 3 ANOVA showed a significant main effect of context ($F(2,24)=20.3$, $p<0.0001$). There was also a main effect of nonword ending ($F(2,24)=12.3$, $p<0.001$) with the sound /əd/ being most often spelt 'ed', followed by /t/

and then /d/. This effect appeared to be independent of presentation context, with no significant interaction between the two ($F(4,48)=2.3$, n.s.).

7.4 Discussion

The traditional dual-route model described in Chapter 2 prescribes that nonwords are spelt using the non-lexical processing route. To recap, within this route a nonword is segmented into phonemes and each phoneme is mapped onto a grapheme using phoneme-grapheme conversion rules. These rules are essentially mappings between phonemes and highest contingency graphemes, that is, the letters which are most often used to spell a phoneme in real words (Barry and Seymour, 1988). This model of nonword spelling has been used to demonstrate impairment in lexical and non-lexical processing in both adults and children. Where nonwords are not spelt using the highest contingency graphemes, the non-lexical processing route in spelling is assumed to be impaired.

Three findings in this experiment suggest that nonwords are not spelt purely by non-lexical processes, and that a default model of spelling needs to allow for interaction between the lexical and non-lexical routes. The first finding is that nonwords are not necessarily spelt using the highest contingency phoneme-grapheme mappings. If a phoneme within a nonword is the same as the pronunciation of a morpheme, the the spelling of the morpheme may be used. We may conclude that lexical information can therefore be used in spelling nonwords, although this interpretation depends on the assumption that morphemes are stored in the lexicon. This assumption is based on the suggestion by Morton (1980) that morphemes (word stems and affixes) are stored in the lexicon. It is also assumed that morphemes are not stored in phoneme-grapheme conversion rules, since these are derived from word stems in the lexicon, rather than from the derivatives of these words (e.g. past participle and plural forms). These assumptions about the representation of information in the lexicon and phoneme-grapheme conversion rules, and the derivation of these rules have yet to be tested thoroughly.

If the morpheme is actually stored non-lexically, and not accessed in the lexicon, it means that accessing a morpheme in the process of nonword spelling does not in itself constitute interaction between lexical and non-lexical processing. However, if the morpheme is stored in the lexicon and can be used in spelling nonwords, this implies that nonword spelling cannot be regarded simply as a non-lexical process. Previous research has shown that the selection of a grapheme can be influenced by hearing a real word before the nonword (Campbell, 1983; Campbell, 1985; Barry and Seymour, 1988). If the real word and the nonword contain the same phoneme, and there is more than one common spelling for this phoneme, the spelling used in the real word is likely to be primed for use in the nonword. This means that lexical information (the preceding word) can increase the activation of a phoneme-grapheme conversion rule. However, in these priming experiments, the grapheme which is used in the nonword is still accessed within the phoneme-grapheme conversion rules. In the experiment described in this chapter, the spelling of a sound is accessed within the lexicon.

This result differs from previous research which assumes that graphemes are spelt using the highest contingency phoneme-grapheme mappings. However, it supports research which has shown the influence of lexical information on nonword spelling, and extends it to suggest that lexical information can be used directly in nonword spelling. This argument depends implicitly on the assumption that morphemic information is stored in the lexicon only.

However, even if the morpheme ‘ed’ and its pronunciations are stored non-lexically, there is still a lexical effect at a higher level, i.e. the context effect. This is the second finding from the experiment: that the syntactic context in which a nonword is presented affects the use of a morphemic spelling. The context-sensitivity in this experiment is interpreted as the heightened activation of a morpheme in the lexicon by the expectation of a nonword being in a particular syntactic category when it is presented. The morpheme 'ed' is a verb morpheme; therefore the expectation of a verb activates morphemes which may be used in verbs. It is possible that other verb endings, such as the singular ending 's', may also be activated. The morpheme which is activated in the lexicon will be associated with its pronunciations (/d/, /t/ and /əd/). Thus once it is activated, if the nonword actually ends in one of these sounds, the morpheme is selected.

This context-sensitivity in the selection of a spelling of a sound cannot be accounted for in the dual-route model's prescription of nonword spelling. The use of 'higher' levels of information in the process of activating a morpheme suggest that there is input from the cognitive system into the lexicon. Thus the activation of an orthographic unit may be influenced by both phonetic and syntactic information. In this experiment, the assumption that the morpheme 'ed' is stored only in the lexicon implies that there is input from the cognitive system to the lexicon. However if this is incorrect and the morpheme is stored in the phoneme-grapheme conversion rules, it is still possible that the cognitive system has input to the phoneme-grapheme conversion process. Phoneme-grapheme mappings with specific syntactic functions would be automatically activated by the expectation of a word in a particular syntactic category.

The third finding is that the use of a morpheme is reduced when the frequency of alternative spellings increases. This suggests that when activated by a combination of phonetic and syntactic information, graphemes and morphemes compete for selection. In this experiment, the variable 'type frequency' was found to influence the competition from non-morphemic spellings. Type frequency refers to the number of English words in which a sound is spelt in a particular way. This finding is consistent with Barry and Seymour's (1988) experiment in which it was found that the type frequency of sound-to-spelling mappings determine which one will be selected.

7.5 Conclusions

The experiment described in this chapter showed that lexical information in the form of morphemes can be used in nonword spelling. Furthermore, it showed that the use of a morpheme is influenced by two factors: the context in which the nonword is presented, and the competition from non-morphemic spellings. Overall this suggests that, contrary to the dual-route model of spelling, there is interaction between the lexical and non-lexical routes and that there is input from the cognitive system in nonword spelling. The next chapter describes a similar experiment which is carried out to see if children demonstrate the same effects, but explores in more detail the nature of competition between morphemic and non-morphemic spellings.

CHAPTER 8

Context and frequency effects in children's nonword spelling

8.1 Introduction

In Chapter 7 it was shown that adults could use spelling knowledge of morphemes to spell nonwords. It was also found that the syntactic context in which a nonword was presented affects the use of a morphemic spelling. Furthermore, increased competition from non-morphemic spellings makes the use of a morphemic spelling less likely.

These three findings add support to existing research which suggests that the dual-route model of spelling needs to allow for interaction between the two routes. Previous research has shown that the spelling of real words (or prime words) heard just before a nonword can influence (prime) the spelling produced for a stimulus nonword (Campbell, 1983; Campbell, 1985; Barry and Seymour, 1988), an effect called 'lexical priming'. Also, experiments have shown that hearing a word semantically related to a prime word can lead that prime word to have a similar influence on the spelling of a nonword (Seymour and Dargie, in press), an effect called 'associative priming'. For example, hearing the word 'vatican' before the nonword /boup/ can cause the nonword to be spelt 'bope' (rather than, say, 'boap') since the word 'vatican' is associated with the word 'pope'. The word 'pope', although not heard, subsequently primes the spelling of the nonword. Both the lexical priming and associative priming effect suggest that the lexical information primes phoneme-grapheme mappings during the spelling of nonwords.

The results from Chapter 7 suggest that, in addition to priming non-lexical information, lexical information (morphemes) can be used directly in the spelling of nonwords. Furthermore, the priming effect of syntactic context on the use of a morpheme suggests that the cognitive system may exert an influence on the activation of items in the lexicon. Finally, the effect of the type-frequency of non-morphemic spellings suggests that lexical and non-lexical information may compete directly.

These inferences about the interaction between lexical and non-lexical information are based on the assumption that the morpheme is stored only in the lexicon, and not represented in non-lexical phoneme-grapheme mappings. This issue is largely unresolved, however, and the assumption is based on a suggestion by Morton (1980) about the 'grapheme output logogen system' rather than on a series of experiments. If the lexicon actually contains the derivatives of word stems, and the non-lexical phoneme-grapheme rule system contains sound-to-spelling mappings for morphemes derived from this lexicon, it may be that it is only non-lexical graphemes which are being used in this experiment, as in the experiments by Campbell (1983, 1985) and Barry and Seymour (1988).

In this chapter, it is again assumed that morphemes are stored in the lexicon. The experiment in this chapter looks at the use of these morphemes in spelling nonwords, but also explores in more detail the competition between morphemic spellings and alternative, non-morphemic spellings. Three elements of competition are proposed and examined: non-morphemic frequency, morphemic frequency and lexical frequency. To support the argument for an effect of non-morphemic frequency, an (unpublished) study by Campbell and Wright[1] is described where the data appear to demonstrate this effect, although the design of the experiment did not control for it.

8.1.1 Non-morphemic frequency

The effect of non-morphemic frequency was examined in the previous chapter. It was shown that the morpheme 'ed' could be pronounced in three ways: /d/, /t/ and /əd/. The non-morphemic spellings for each of these sounds were categorised as having high, medium and low type frequencies respectively. That is to say, there were more words ending in the sound /d/ (e.g. 'hand') than there were in the sounds /t/ (e.g. 'fact') and /əd/ (e.g. 'splendid'), where that sound did not represent the past participle morpheme 'ed'. Where a sound had high type frequency, the morpheme 'ed' was less likely to be used; this was attributed to increased competition from the non-morphemic spellings.

However, that experiment used different terminal sounds to demonstrate different levels of non-morphemic frequency. It is possible that other factors may have differentiated between the three endings, such as the fact that past participles sometimes end in the letter 't' (e.g. 'spelt', 'kept') whereas they never end in the letter 'd' or the letters 'id'. Another factor may have been that the nonwords ending in /əd/ had two syllables, whereas those ending in /d/ and /t/ had only one syllable. It may therefore be better to examine the effect of non-morphemic

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[1] I would like to thank Ruth Campbell for lending me her data and allowing me to use them in this thesis.

frequency in nonwords ending in the same phoneme. The experiment described later in this chapter does precisely that, examining non-morphemic frequency effects in the spelling of different nonwords which all end in the sound /d/.

Campbell and Wright recently carried out a study which examined the effect of presentation context on children's use of morphemes in spelling nonwords. Their data appear to demonstrate effects of non-morphemic frequency, although they did not control for this in their experiment. The aim of their experiment differed from the study described in the previous chapter in three main ways. Firstly, it was carried out with children rather than adults, and secondly, it looked at the use of two morphemes in spelling nonwords rather than one: the past participle morpheme 'ed' and the plural noun marker 's'. (The study in Chapter 7 looked only at the use of 'ed'.) Thirdly, it looked at only one pronunciation of the morpheme 'ed' (that is, /t/) compared to three pronunciations in Chapter 7. Accordingly it is possible to investigate non-morphemic frequency effects within nonwords ending in the same phoneme. Since their results have not been published, their experiment is summarised here with their permission, and the apparent effect of non-morphemic frequency is described.

Fifty-one children between the ages of 6 and 12 (with a mean age of 8.75) took part in their experiment. In a within-groups design, nonwords were presented in two contexts: one where the use of the morpheme was primed, and the other where the use of the morpheme was unprimed. For the 'ed' morpheme, the priming context was presentation as a verb; for the 's' morpheme, the priming context was presentation as a plural noun.

To test for the use of the morpheme 'ed' the children were presented with sixteen nonwords ending in the diphone /st/, e.g. /brist/ (rhymes with 'list') and /fɔst/ (rhymes with 'lost'). In real words these two phonemes occur at the end of past participles such as 'passed' where the phoneme /t/ is spelt 'ed', and at the end of non-past participles such as 'list', where the phoneme /t/ is spelt 't'. Each nonword was presented in a noun context in the first session, e.g. 'I saw a /brist/ across the river', and in a verb context in the second session, e.g. 'Quickly, I /brist/ across the river'. It was expected that when presented as a verb, the nonword ending would be spelt with the morpheme 'ed' (e.g. 'Quickly, I brissed across the river'), and when presented as a noun, the ending would be spelt 't' (e.g. 'I saw a brist across the river'). Thus the verb context was expected to prime the use of the morpheme 'ed'. There were no control conditions in which no priming context was used; thus it appears that the noun context was expected to act as a control condition where the verb morpheme was not primed.

To test for the use of the morpheme 's' the children were presented with 16 nonwords. Thirteen of these ended with the phoneme /z/, e.g /pri:z/ (rhymes with 'tease') and 3 ended in the diphone /ks/, e.g. /drʌks/ (rhymes with 'trucks'). The phoneme /z/ occurs at the end of plurals such as 'cars' and is spelt 's', and at the end of non-plurals such as 'rose' and 'sneeze' where it is usually spelt 'se' or 'ze'. The diphone /ks/ occurs at the end of plurals such as 'trucks' where the phoneme /s/ is spelt 's', and at the end of non-plurals such as 'box' where the whole diphone is spelt 'x'.

Each nonword was presented once as a singular noun, e.g. 'Make a /pri:z/ if you can', and once as a plural noun, e.g. 'Make as many /pri:z/

as you can'. It was expected that where the nonwords were presented as plural nouns, the terminal phoneme would be spelt with the morpheme 's' (e.g. 'Make as many preas as you can') and where it was presented as a single noun it would be spelt by the non-morphemic spelling 'se', 'ze' or 'x' (e.g. 'Make a preeze if you can'). Thus the plural noun context was expected to prime the use of the morpheme 's'. The single noun was not expected to prime the use of a non-morphemic spelling; rather this would be used by default because it is the highest contingency non-morphemic spelling for that phoneme.

Each nonword was written by the children after it had been spoken by the experimenter. (The surrounding sentence was not written down.) The data were scored as follows: for each nonword, the number of children who spelt it with a morphemic ending was counted. This was carried out for the nonword as it was presented in each condition (primed morpheme and unprimed morpheme). Campbell and Wright converted the number of children into a percentage for each nonword, i.e. the percentage of children who spelt that nonword with a morphemic ending, and this was averaged over the set of 32 nonwords. The resulting scores shown in Table 8-1 therefore represent the mean percentage of children spelling the nonwords in each condition (primed and unprimed) with a morphemic ending.

Using 's'		**Using 'ed'**	
Primed	Unprimed	Primed	Unprimed
70.1	43.6	18.6	4.4

TABLE 8-1. Percentage of children (N=51) using a morpheme to spell nonword endings in primed and unprimed conditions

Campbell and Wright did not analyze their data further and so the rest of this section examines their data in more detail. These results show that more children use a morphemic spelling in a nonword when the word is primed (70.1% and 18.6%) than when it is not primed (43.6% and 4.4%). Also, more children use 's' than 'ed' (70.1% and 43.6% against 18.6% and 4.4%). Both these trends are statistically significant ($X^2=63.94$, df=1, $p<0.001$). The effect of presentation condition was expected and supports the influence of context described in Chapter 7.

The difference between overall use of the 's' morpheme and the 'ed' morpheme is unexpected. Also unexpected was that the effect of priming appears to be larger for 's' than it is for 'ed'. This is indicated by the fact that 26.5% more children used the 's' morpheme in the primed condition than in the unprimed condition, but only 14.2% more children used the morpheme 'ed' in the primed condition than in the unprimed condition.

One possible reason why the 's' spelling was used more often than the 'ed' spelling may be that for the nonwords used, there were fewer non-morphemic alternatives to the 's' spelling than there were to the 'ed' spelling. The importance of the alternatives should be noted here because it is against these that the morpheme is competing for selection in spelling a nonword. For example, when spelling /t/ at the end of a nonword, we have two types of spelling competing: the usual past participle spelling 'ed' (as in 'passed'), and non-morphemic spellings such as 't' (as in 'past').

In Campbell and Wright's study there was a difference between the stimuli used in the 'ed' group and the 's' group which may account for the difference between the use of these morphemes. All the nonwords in the 'ed' group ended in the phoneme cluster /st/, e.g. /neist/. This rhymes with both morphemic occurrences of the phoneme /t/, e.g. 'faced', and non-morphemic occurrences of the phoneme /t/, e.g. 'waste'. Thus the nonwords in this part of their study could possibly be spelt morphemically or phonetically.

However, in the 's' group, the nonword stimuli ended in different types of phoneme string: 12 of the 16 nonwords ended in a vowel plus /z/, e.g. /plouz/ (rhymes with 'hose' and 'toes'), one ended in the consonant cluster /nz/ - this was /grʌnz/ (rhymes with 'runs') - and three ended in the consonant cluster /ks/, e.g. /dʒiks/ (rhymes with 'fix' and 'sticks'). For some of these endings, there are morphemic as well as non-morphemic spellings. For example, the ending /eiz/ can be spelt morphemically as in 'ways', 'trays' and 'rays', or it can be spelt non-morphemically as in 'blaze', 'phase' and 'praise'. For other endings, there are considerably less non-morphemic occurrences. For example, the ending /aːz/ occurs morphemically in the words 'cars', 'stars' and 'bars'. The only word I can think of which ends in this phoneme string is 'vase'. Thus for a nonword ending in this phoneme string, there is hardly any competition against the 'ed' morpheme. It would then be expected that the 'ed' morpheme would be more easily selected for this nonword than for the nonword ending in /eiz/, where there is more competition from non-morphemic spellings. The two parts of the study therefore differed not only in terms of the morpheme which was being studied, but also in the range of nonword endings used, and in the amount of competition from non-morphemic spellings.

A further analysis of Campbell and Wright's data carried out by the author bears out the expectation that increased non-morphemic frequency results in less use of a morphemic spelling. To assess non-morphemic frequency, a count was taken of monosyllabic real words which rhymed with each nonword. Only words with a frequency of over 10 per million (Thorndike and Lorge, 1944) were included. This meant that rarer words which it was assumed that children would be less likely to use, such as 'zest' and 'guise', would be excluded. The real words which rhymed with nonwords in the 'ed' group are shown in Table 8-2 and the real words which rhymed with nonwords in the 's' group are shown in Table 8-3.

Ending	Real words	Total
/æst/		0
/est/	best breast chest crest guest quest jest lest nest rest test vest west	13
/oust/	boast coast ghost post host most roast toast	8
/ʌst/	bust crust trust just must rust dust	7
/ɜːst/	burst first worst	3
/eist/	paste taste haste waste	4
/ist/	fist list mist wrist	4
/ɔst/	cost frost lost	3

TABLE 8-2. Real words rhyming with the end of the nonwords in the 'ed' group

For the 'ed' group, there was an average of 5 real words which rhymed with each nonword, and for the 's' group, there was an average of 2.91 real words which rhymed with each nonword. Thus the 'ed' group has almost twice as many real words competing with the morphemic ending as the 's' group. Because of this difference, it is entirely possible that in each group of nonwords there is a negative correlation between the number of real word rhymes for any nonword ending, and the use of a morpheme in spelling a nonword with that ending. Thus we would expect a nonword which had no non-morphemic rhymes to be spelt using the morphemic spelling.

Ending	Real words	Total
/aːz/	vase	1
/eiz/	blaze phase phrase gaze graze praise raise daze	8
/ouz/	close prose nose rose pose those	6
/ʌnz/		0
/iːz/	breeze freeze please seize tease these	6
/əːz/		0
/ɔks/	box fox	2
/ɔiz/	noise poise	2
/aiz/	prize size rise wise	4
/iks/	fix mix six	3
/ʌks/		0

TABLE 8-3. Real words rhyming with the end of the nonwords in the 's' group

To test this, the correlations between the number of rhyming words, and the number of children using a morphemic spelling were calculated. These are shown in Table 8-4, where 'n' refers to the number of stimulus nonwords presented in each condition.

Use of 'ed'		Use of 's'	
Primed	Unprimed	Primed	Unprimed
0.252	-0.188	-0.672**	-0.497*

TABLE 8-4. Correlations between non-morphemic competition and use of a morphemic spelling (n=16) (* $p_{1\text{-tail}}<0.05$, ** $p_{1\text{-tail}}<0.01$)

The validity of these correlations is limited by the fact that the use of a morphemic spelling was measured by Campbell and Wright in terms of the number of children who used that spelling, rather than the number of times individual children used a morphemic spelling. This is a limitation because within an individual child, the number of rhyming real words will affect the number of times they choose a spelling; this will be reflected indirectly in the overall number of children who use this spelling, but it would be better if we had a direct measure of how often each child used a particular spelling.

However, the correlations between the number of real word rhymes and the use of the morphemic spelling for the morpheme 's' are as expected: they are negative and significant for both the primed condition ($r=-0.672$, $p_{1\text{-tail}}<0.01$) and the unprimed condition ($r=-0.497$, $p_{1\text{-tail}}<0.05$). This implies that the more non-morphemic incidences of a spelling there are, the more competition there is against the morphemic spelling, and the less likely this is to be used.

The correlations for the 'ed' morpheme, on the other hand, are not as expected. Firstly, they are low, and secondly, one of them is positive. This may be partly explained by 'confusions' in Campbell and Wright's data. Records of the results list stimulus nonwords in different phonetic notations, so the actual pronunciation of the nonword stimuli is unclear. Furthermore, one of their nonwords, /væst/, is very similar to the real word 'vast' and may have been perceived as such by the children during the experiment.

The effect of the number of competing non-morphemic spellings can be seen more clearly if we look at the effect on the spelling of individual nonwords with differing numbers. Table 8-3 shows that in the 's' group there are 6 monosyllabic real words ending in the phoneme string /iːz/, where the /z/ ending occurs non-morphemically, e.g. 'breeze' and 'tease'. By comparison, there are no real words ending in the phoneme string /ʌnz/ (rhymes with 'guns'), where the /z/ phoneme occurs non-morphemically. Thus we would expect that there would be less competition against the 's' morpheme in spelling the nonword /grʌnz/ than there would be in spelling the nonword /priːz/. As a result we may find more morphemic spellings for the nonword /grunz/, e.g. spelt 'gruns' or 'grunns', than we would for the nonword /priːz/. A morphemic spelling for /priːz/ may be 'preas'; non-morphemic spellings of this nonword may be 'preeze', or 'prease', for example.

Closer analysis of Campbell and Wright's data bear out this prediction. The percentage of children using the morphemic spelling 's' for the nonwords /priːz/ and /grʌnz/ in the primed and unprimed conditions is shown in Table 8-5, where N refers to the number of children in the study.

/priːz/		/grʌnz/	
Primed	Unprimed	Primed	Unprimed
64.0%	28.6%	84.2%	70.8%

TABLE 8-5. Percentage of children using a morphemic spelling (N=51)

Most children use the morphemic ending 's' for the nonword ending in /ʌnz/, in both primed and unprimed conditions. Less children use the morphemic spelling for the nonword ending in /iːz/ (X^2=46.353, df=1, $p<0.001$). This suggests that the number of competing non-morphemic items in the lexicon does indeed affect the provision of an alternative spelling in this particular case.

However, this effect is only demonstrated for one nonword and thus we cannot show conclusively that the number of non-morphemic alternatives determines selection of a morpheme using Campbell and Wright's data. The experiment described below systematically examines the effect of non-morphemic information using a set of nonwords with the same phonetic ending. Two other effects which were examined using the same stimuli were that of 'morphemic frequency' and 'lexical frequency'.

8.1.2 Morphemic frequency

In spelling a nonword whose end sound may be spelt as a morpheme (e.g. /d/ may be spelt 'ed'), the selection of the morpheme over non-morphemic spellings may be influenced by the 'likelihood' that the morpheme may be found in that particular phonetic context. In real words, the morpheme 'ed' does not occur after the 'short' vowel sounds (e.g. /ɔ/ as in 'pot'). It only occurs after the 'long' vowel sounds (e.g. /ei/ as in 'swayed') and after all consonants (e.g. /l/ as in 'peeled'). Hence, the morpheme only occurs after verb stems which end in a phoneme in this set, such as 'sway' or 'peel'.

However, within this set of permissible verb stem endings, some of the phonemes will occur in more past participles than others. For example, it may be the case that there are more regular past participles ending in the phonemes /ld/ (such as 'peeled' and 'filled') than in the phonemes /eid/ (such as 'swayed'). Intuitively, it may be that, in the latter case, past participles ending in these phonemes tend to be irregular, as in 'made' or 'paid'. Thus it might be expected that nonwords ending in these phonemes are less likely to be spelt with the morpheme 'ed', since there are fewer past participles with a morphemic spelling for that phoneme sequence. The number of regular past participles ending in a certain phoneme sequence may be referred to as the 'morphemic frequency' of the terminal phonemes.

8.1.3 Lexical frequency

When choosing between a morphemic spelling and a non-morphemic spelling for a nonword ending it is possible that the preceding phoneme is taken into account. This is the phoneme which comes immediately before the sound which may be spelt as a morpheme. For example, in the nonword /neid/ (rhymes with 'weighed'), the terminal phoneme /d/ is a pronunciation of the morpheme 'ed' and may therefore be spelt as such. The preceding phoneme is the vowel /ei/.

In real words, the morpheme 'ed' only occurs after certain phonemes, namely those which occur at the end of verb stems (e.g. /m/, as in 'aimed' and /ei/ as in 'swayed'). This morpheme does not occur after any of the short vowels (e.g. /ɔ/ as in 'pot'), principally because no verbs end in these phonemes. As a result, it may reasonably be expected that a nonword ending would not be spelt 'ed' when preceded by the short vowel phonemes, such as in the nonword /nid/, for example. A phoneme which occurs frequently at the end of real words may therefore be more likely to be followed by a morphemic spelling at the end of a nonword, than a phoneme which occurs less often at the end of real words. If this is the case, we may say that the number of words in the lexicon ending in a particular phoneme, i.e. the 'lexical frequency' of a terminal phoneme, affects the use of a morpheme in nonword spelling.

8.2 Method

This experiment was designed to investigate the effects of presentation context (noun vs. verb context) and three types of word frequency on the use of the morpheme 'ed' in spelling nonwords: non-morphemic frequency, morphemic frequency and lexical frequency.

8.2.1 Design

The basic design of the study was that a single set of 40 nonwords was to be presented to each subject. The nonwords all ended in the phoneme /d/, and in each nonword this was preceded by a vowel phoneme. The nonwords were presented in two contexts: verb and noun. It was expected that when presented in the verb context, the child would be more likely to spell the nonword ending with the 'ed' past participle morpheme (Hypothesis (a)).

The data were analyzed in terms of three types of word frequency corresponding with the nonword endings: non-morphemic frequency, morphemic frequency and lexical frequency. For each analysis, the nonwords were divided into two groups: high frequency and low frequency. The number of nonword endings spelt with the morpheme 'ed' in each group were compared. Effects of each type of word frequency were expected in the following directions:

(i) nonword endings with high non-morphemic frequency would be less likely to be spelt 'ed' than nonword endings with low non-morphemic frequency (Hypothesis (b));

(ii) nonword endings with high morphemic frequency would be more likely to be spelt 'ed' than nonword endings with low morphemic frequency (Hypothesis (c)); and

(iii) nonword endings with high lexical frequency would be more likely to be spelt 'ed' than nonword endings with low lexical frequency (Hypothesis (d)).

The experiment used a single group of children and gave them all the nonwords to spell, in both presentation conditions, 'noun' and 'verb'. The children were to be seen in two separate sessions. It was decided that in the first session, half the nonwords should be presented as nouns and the other half as verbs. In the second session, those formerly presented as nouns would be presented as verbs, and vice versa. There was a gap of one to two weeks between the sessions.

8.2.2 Subjects

The subjects were 32 children attending a middle school in Milton Keynes. There were 19 girls and 13 boys. All the children were in the fourth year; the mean age was 12 years and 2 months. The youngest child was 11 years and 10 months; the oldest child was 12 years and 8 months. None of the children was receiving extra tuition for any reading or spelling difficulties.

The children's spelling ability was determined on the Schonell Graded Spelling test (Schonell and Wise, 1985). The test consists of two word lists, one of 'irregular' words and one of 'regular' words. The two lists are intended to enable a comparison between a child's ability to spell 'phonetic' and 'non-phonetic' words respectively. The irregular words are those 'containing such pitfalls as silent letters, double letters, indeterminate vowels and confusing digraphs' (p. 37); examples are 'again', 'laugh' and 'neither'. The regular words contain 'units having a high degree of correspondence between audible sound and visible symbol' (p. 37); examples of these are 'winter', 'punish' and 'visited'.

Performance on each list is scored as the number of words spelt correctly out of 60 words. The mean scores of boys and girls on the irregular and regular word lists are shown in Table 8-6. The standardised scores for children aged 12 are also shown for comparison. These are taken from Schonell and Wise (1985).

	Irregular words		**Regular words**	
	Boys (n=13)	Girls (n=19)	Boys (n=13)	Girls (n=19)
Mean score	37.2	40.5	43.7	44.2
Standardised score	45.5	47.7	51.3	52.0

TABLE 8-6. Scores on the Schonell spelling test (out of 60)

The scores on the regular words are higher than the scores on the irregular words for both girls ($t=5.435$, $df=18$, $p_{1\text{-tail}}<0.001$) and boys ($t=5.836$, $df=12$, $p_{1\text{-tail}}<0.001$). The mean scores are all lower than the standardised scores. In both the regular and irregular lists of words, boys and girls scored at least the number expected of 9 year olds, but less than the norm for 10 year olds. Thus the mean spelling age of the children is approximately 9 years. This is not given as an exact measurement, as the Schonell Graded Spelling test is essentially designed for use with 'backward spellers of all ages', and therefore 'they are not really effective as attainment tests for pupils beyond the age of 10 years' (p. 37).

8.2.3 Materials

The materials consisted of a set of 40 nonwords ending in the phoneme /d/.

8.2.3.1 Constructing the nonword stimuli

A set of 40 nonwords was made up. The nonwords were all monosyllabic and all of them ended in the consonant phoneme /d/. The initial consonant phonemes and diphones used are as follows:

Phonemes: /d/ /f/ /h/ /m/ /t/ /n/

Diphones: /bl/ /br/ /dr/ /fl/ /fr/ /gr/ /kl/ /kr/ /pl/ /sk/ /sl/ /sn/ /sp/ /st/ /tr/

A restricted set of 9 vowel phonemes was used. The set was restricted because it was necessary that, when spelling the nonword, it would be equally plausible to spell the terminal /d/ phoneme with the letter 'd' or with the past participle morpheme 'ed'. By 'plausible' I mean that real words exist with both spellings. For example, the vowel sound /ou/ followed by /d/ can be found in both past participles where the 'ed' spelling is used (e.g. 'mowed') and in non-past participles where a 'd' spelling is used (e.g. 'toad'). For other vowel phonemes, although they occur in real words followed by the phoneme /d/, they never occur followed by this phoneme when it is spelt 'ed'. This is mostly the case with the 'short' vowel phonemes because they do not occur at the end of verb stems. These vowel phonemes are shown in Table 8-7.

Vowel phoneme	Examples
/e/	head, red
/a/	mad, glad
/i/	did, hid
/ɔ/	odd, rod
/ʌ/	mud, thud
/u/	good, should

TABLE 8-7. Vowel phonemes which are never followed by the morpheme 'ed'

Although they are never followed by the morpheme 'ed', these short vowel phonemes may still occur in past participles. For example, the phoneme /e/, occurs in the word 'said'. However, the spelling of the past participle may be considered 'irregular' in that the terminal phoneme /d/ is not spelt 'ed'. Thus it is only the roughly equal occurrence of a vowel phoneme in 'regular' past participles, and non-past participles ending in /d/ that allows it to be used in this study. This manipulation of the nonword stimuli was so that any preference for one spelling over the other could be attributed to the independent variable of presentation context, and not to an 'ed' or 'd' spelling in that situation being unrealistic.

One vowel phoneme which was also not used was /ɛ/ as in 'fair'. This occurs frequently in regular past participles: for example, 'scared', 'cared', 'paired', 'shared', 'dared' etc. However, it occurs rarely in non-past participles when followed by /d/, one example being the word 'laird'. Again, because of the imbalance in morphemic and non-morphemic occurrences, this vowel phoneme was excluded from the stimuli.

One more vowel phoneme excluded from the stimuli was /iː/ (as in 'me'). This was excluded because it is often spelt 'ee' when occurring in a monosyllabic word, e.g. 'teeth', 'feet'. If a nonword containing this vowel sound and ending in the phoneme /d/, such as /tiːd/, was spelt 'teed', we would not be able to establish whether the terminal phoneme had been spelt 'd' or 'ed'. This is because the second 'e' could be said to belong to either the vowel grapheme 'ee' or the past participle morpheme 'ed'. The vowels which were included in the study were therefore those for which the most common non-morphemic spelling does not end in the letter 'e'.

The vowel phonemes used are shown in Table 8-8. The second and third columns of this table show examples of common spellings of the vowel sound in real words when it is followed by the phoneme /d/.

Phoneme	Morphemic spelling	Non-morphemic spelling
/ɔi/	toyed	void
/ai/	died	hide
/ei/	stayed	made
/əː/	stirred	bird
/au/	ploughed	loud
/aː/	scarred	hard
/uː/	glued	food
/ou/	rowed	code
/ɔː/	sawed	cord

TABLE 8-8. Vowel phonemes used in the study and various spellings of the terminal phoneme /d/

The second column is for morphemic occurrences. A morphemic occurrence is where the phoneme /d/ represents, and is spelt as, the past participle morpheme 'ed' e.g. 'died'. The third column is for non-morphemic occurrences of the phoneme /d/. A non-morphemic occurrence is when this sound occurs at the end of a word such as 'hide'. There were either 4 or 5 nonwords constructed for each of the 9 vowel phonemes. The final set of nonwords is shown in Table 8-9. These 40 nonwords were fed into a computer program which reproduced them in the form of a randomised list. The list was then checked to ensure that no consecutive items contained the same vowel phoneme or the same initial consonant phoneme(s). If two such nonwords were found together, one of them was swapped for another nonword in the list so that this criterion could be met.

Phoneme	Nonwords
/ɔi/	/skɔid/ /krɔid/ /hɔid/ /mɔid/
/ai/	/naid/ /blaid/ /faid/ /staid/ /graid/
/ei/	/kreid/ /heid/ /teid/ /deid/ /skeid/
/əː/	/drəːd/ /snəːd/ /fləːd/ /kləːd/
/au/	/fraud/ /blaud/ /graud/ /spaud/
/aː/	/snaːd/ /blaːd/ /graːd/ /plaːd/
/uː/	/tuːd/ /fruːd/ /pluːd/ /sluːd/
/ou/	/doud/ /ploud/ /broud/ /foud/ /skoud/
/ɔː/	/krɔːd/ /slɔːd/ /grɔːd/ /trɔːd/ /blɔːd/

TABLE 8-9. Nonwords used in the study

8.2.3.2 Making up the sentences

A verb sentence was constructed around the first nonword, and a noun sentence around the second nonword. An example of a verb sentence is:

'The child /skɔid/ in the playground.'

An example of a noun sentence is:

'My dog chewed up the /skɔid/.'

Care was taken not to construct a sentence where the nonword sounded like a real word which may be likely to be found in that context. Alternate verb and noun sentences were similarly constructed around the rest of the nonwords. Filler sentences, each containing a nonword, were inserted between each of the 40 stimulus sentences, e.g.

'A /brawk/ appeared on the horizon.'

The filler nonwords were all monosyllabic and ended in consonant phonemes other than /d/. Each nonword was positioned in its sentence so as to vary the position of the nonword from sentence to sentence. The purpose of this variation was to avoid the possible anticipation of the nonword being in a particular position in every sentence. If this occurs, the contextual sentence may be ignored while the child waits for, for example, the last word in the sentence which they expect to be the nonword. Since one of the aims of the experiment was to study the effect of context on nonword spelling, it was important that the context was not ignored.

The final list of 80 sentences was called 'List A' and is shown in Appendix G. This was to be presented to the children in their first session. A second list, 'List B', was made up for the second session. This consisted of an edited version of List A. Firstly, the first and second halves of List A were interchanged so that nonwords presented in the first half of List A occurred in the second half of List B and vice versa. Secondly, the contexts of the 'verb' and 'noun' nonwords were swapped.

Thus, nonwords which had previously been embedded in the noun sentences were now embedded in the verb sentences, and vice versa. The filler sentences remained largely the same in List B as they were in List A. Some changes were made to these following the presentation of List A, where it appeared that a filler nonword resembled a real word too closely. Although this was not thought to directly affect the processing of the nonwords ending in the phoneme /d/, it was felt to be important that the subjects did not generally perceive the nonwords to be real words which had been altered slightly, since this may cause them to search for similar real words and use them as a basis for spelling the nonword. List B is shown in Appendix H.

8.2.4 Procedure

All the subjects were first seen individually and given the Schonell graded spelling test. They were also given a few practice nonwords to spell, and were told that they would be spelling some more of these later. These nonwords were the filler nonwords, and were presented without a surrounding sentence.

In the first nonword spelling session children were seen in groups of 4. They were seated separately and told that they were going to hear some sentences and that there would be a nonword contained within the sentence, just like the nonwords they had heard earlier. They were told that they had to say the nonword out loud together, and then write it down. This was to ensure that they had heard the nonword correctly. The author then read out each sentence in List A, waited for the group to finish writing down the nonword and cover it up with a piece of paper, and then went on to the next sentence. The children were watched to make sure they didn't look back at the previous nonwords. The second session was similarly carried out in groups of 4 children at a time, but this time using the sentences in List B.

The nonword spellings were analyzed for an effect of context, and for three effects of word frequency: non-morphemic frequency, morphemic frequency and lexical frequency. Thus three analyses of word frequency were carried out, where the nonwords were divided into those with high frequency endings and those with low frequency endings. In each type of word frequency, 'frequency' refers to the type frequency of rhyming words; that is, the number of real words that rhyme with the nonword endings, rather than the token frequency of these words, i.e. how often they are used in written or spoken text.

8.2.4.1 Calculating non-morphemic frequency

The non-morphemic frequency of the nonword endings was determined as follows. For each of the 9 nonword endings (/oud/, /uːd/, /aud/, /eid/, /aid/, /ɔid/, /ɔːd/, /aːd/ and /əːd/) a count was taken of monosyllabic real words with that ending whose frequency of occurrence in text was greater than 10 per million (Thorndike and Lorge, 1944). This meant that low frequency words such as 'shroud' (9 per million) and 'ode' (6 per million) were excluded. Other words above this frequency were left in even if it was considered that the children would not know them, e.g. 'shrewd' (13 per million) and 'bade' (33 per million). This cut-off point was taken because it was thought that the children in the experiment would not know less frequent words and so they would not affect the child's spelling. However, including them in the word count could cause a particular ending to be classified as being of high frequency when, for a child, the ending is of low frequency (i.e. the child does not know many words with this ending). The point of a non-morphemic frequency count was to reflect the frequency of the endings which a child knows.

No past participles were included in this count, whether they were regular past participles ending in the 'ed' morpheme, e.g. 'stayed', or 'irregular' past participles, e.g. 'made' or 'paid'. The resulting word counts are listed in Table 8-10 in descending order of non-morphemic frequency.

Ending	Words	TOTAL
/eid/	aid blade braid fade grade spade trade maid raid wade shade	11
/aid/	bride guide glide pride side slide hide ride wide	9
/ɔːd/	board broad cord ford fraud hoard lord ward	8
/uːd/	brood crude food mood rude shrewd	6
/oud/	code toad load mode road	5
/əːd/	bird word third herd	4
/aud/	cloud proud loud crowd	4
/aːd/	card guard hard	3
/ɔid/	void	1

TABLE 8-10. Non-morphemic frequency of the nonword endings

This table shows that the ending with highest non-morphemic frequency is /eid/, and the ending with lowest non-morphemic frequency is /ɔid/. The nonwords were divided into two groups having roughly the same number of nonwords in each: those with endings of high non-morphemic frequency and those with endings of low non-morphemic frequency. The resulting groups are shown in Table 8-11.

HIGH FREQUENCY			LOW FREQUENCY		
Ending	**Example**	**Nonwords**	**Ending**	**Example**	**Nonwords**
/eid/	fade	5	/oud/	road	5
/aid/	hide	5	/ɜːd/	bird	4
/ɔːd/	cord	5	/aud/	cloud	4
/uːd/	food	4	/aːd/	hard	4
			/ɔid/	void	4
	TOTAL	19		TOTAL	21

TABLE 8-11. High and low non-morphemic frequency nonword endings

The high non-morphemic frequency endings therefore occurred in 19 nonwords, and the low non-morphemic frequency endings occurred in 21 nonwords.

8.2.4.2 Calculating morphemic frequency

A count was taken of the number of past participles ending in each of the nine phonetic endings of the nonword stimuli: /ɔid/, /uːd/, /eid/, /aid/, /oud/, /aud/, /ɔːd/, /ɜːd/ and /aːd/. Only regular past participles were included, i.e. where the spelling of the past participle ended in the morpheme 'ed'. Thus, 'stayed' would be included in the count but 'paid' would not. This was because the count was intended to reflect likelihood of a vowel phoneme being followed by the spelling 'ed'.

Since the word list of Thorndike and Lorge does not include regular past participles, a count was taken of verb stems ending in each of the nine vowel phonemes. Verb stems were excluded from the count if their frequency of occurrence was below 10 times per million words; this cut-off was made for the same reasons as in the previous count. Although the frequency of occurrence of the verb stems will not be the same as the frequency of occurrence of the past participle, it was assumed that the two would be loosely related and that relative frequency would be basically preserved. For instance, as the word 'sew' occurs twice as often as the word 'plough', we can assume that the past participle 'sewed' occurs approximately twice as often as the past participle 'ploughed'.

This example reveals a problem with using the Thorndike and Lorge count: no distinction is made between the frequency of the word 'plough' as it occurs as a noun and as it occurs as a verb. A decision was therefore made to include words which were both a noun and a verb in this count of verbs. A second problem with the Thorndike and Lorge count was that no distinctions are made between homonyms, e.g. there is only one entry for the word 'sow', where this could mean a 'female pig' or to 'plant seed'. For the purpose of this experiment, where a word could be used as a verb, it was included in the count. All the words included in the final count are shown in Table 8-12. They are ranked in descending order of morphemic frequency.

Ending	Words	TOTAL
/aid/	cry die dry dye eye fry lie ply sigh shy spy tie try	13
/ɔːd/	bore claw cure gnaw jaw moor paw pour saw soar store thaw	12
/oud/	crow flow glow owe row sew show slow snow sow toe	11
/eid/	bay play pray slay spray stay stray sway weigh	9
/uːd/	chew crew glue shoe woo	5
/aːd/	bar mar scar star	4
/aud/	bow plough row	3
/əːd/	stir	1
/ɔid/	toy	1

TABLE 8-12. Morphemic frequency of the nonword endings

The first four endings were counted as having high morphemic frequency, and the last five were counted as having low morphemic frequency. The high and low frequency endings are shown in Table 8-13. There were 20 nonwords with high morphemic frequency endings, and 20 with low morphemic frequency endings.

HIGH FREQUENCY			LOW FREQUENCY		
Ending	Example	Nonwords	Ending	Example	Nonwords
/aid/	died	5	/u:d/	chewed	4
/ɔ:d/	bored	5	/a:d/	marred	4
/oud/	showed	5	/aud/	ploughed	4
/eid/	stayed	5	/ə:d/	stirred	4
			/ɔid/	toyed	4
	TOTAL	20		TOTAL	20

TABLE 8-13. High and low morphemic frequency nonword endings

8.2.4.3 Calculating lexical frequency

A lexical frequency count was taken for each of the 9 vowels used in the nonwords. This count consisted of the number of monosyllabic real words which ended in the vowel sound. The stems included in the count were those which occurred more than 10 times per million words of text (Thorndike and Lorge, 1944). Again, this was a cut-off point designed to exclude words which the children may not know. The counts for each vowel phoneme are shown in Table 8-14. They are ordered in descending lexical frequency.

Where a homograph occurred, such as 'sow' (meaning either a 'female pig' or to 'plant seed'), there is only one entry in Thorndike and Lorge's word list. Where a word has different pronunciations, it is therefore included in the count for both vowel phonemes, i.e. 'sow' would be included in the counts for /au/ and /ou/. Where a homonym is pronounced identically for both meanings, it is included only once for that vowel phoneme, e.g. 'tie' (the verb) and 'tie' (the noun).

The first five vowel endings have high lexical frequency (over 20 words per ending) compared to the last four (no more than 10 words per ending). In the previous counts, that of non-morphemic and morphemic frequency, the nonwords have been assigned to either high or low frequency groups with a view to making the number of nonwords in each group roughly even.

Vowel	Words	TOTAL
/uː/	blew blue chew clue crew dew do drew due few glue grew hue Jew knew new shoe slew stew threw through to too true two who woo you	28
/ou/	blow bow crow dough flow foe fro glow go grow ho Joe know lo low no owe row sew show slow snow so sow though throw toe woe	28
/ɔː/	awe bore claw cure door draw for four gnaw jaw law moor more nor ore paw poor pour pure raw saw shore soar sore store straw thaw war	27
/ai/	buy by cry die dry dye eye fly fry high I lie pie ply rye shy sigh sky sly spy thigh thy tie try why	25
/ei/	bay day gay gray grey hay J(j)ay lay may pay play pray ray slay spray stay stray sway they tray way weigh	22
/au/	bough bow brow cow how now plough row sow thou	10
/aː/	bar car far jar mar scar star ha	8
/əː/	fur her stir per fir	5
/ɔi/	boy Roy toy Troy	4

TABLE 8-14. Lexical frequencies of terminal vowels

However, in this count there seems to be a clear difference between those which are high frequency and those which are low frequency with a large gap between them - no vowel phoneme had a lexical frequency between 11 and 22 words. Thus the nonwords were assigned to high and low frequency groups on the basis of this count alone, and without attempting to make the number of nonwords in each group equal. The high lexical frequency vowels are shown in Table 8-15.

The total number of nonwords containing high lexical frequency vowels was 24. There were 16 nonwords with low lexical frequency vowels. Grouping the vowels strictly in terms of their lexical frequency without balancing the number of nonwords with each ending meant that there was an imbalance in the number of nonwords assigned to each group.

HIGH FREQUENCY			LOW FREQUENCY		
Vowel	**Example**	**Nonwords**	**Vowel**	**Example**	**Nonwords**
/ou/	blow	5	/au/	brow	4
/uː/	clue	4	/əː/	her	4
/ɔː/	for	5	/aː/	bar	4
/ai/	dry	5	/ɔi/	boy	4
/ei/	hay	5			
	TOTAL	24		TOTAL	16

TABLE 8-15. High and low lexical frequency vowels

However, it was thought that this reflected the division between high and low frequency vowels more fairly. The high frequency group had an average of 26 words per ending; the low frequency group, 6.75 words.

8.3 Results

Each child's spellings were scored in terms of the number of nonword endings which were spelt 'ed' (e.g. /graid/ spelt 'gried'). The remaining spellings were mostly either 'd' (e.g. /graud/ spelt 'groud') or 'de' (e.g. /slɔːd/ spelt 'slorde'). The number of morphemic spellings made in the primed condition (verb) and the unprimed condition (noun) were compared to the Schonell scores. The correlation coefficients are shown in Table 8-16, where N represents the number of subjects. The number of 'ed' spellings made in the primed condition correlated with spelling ability on both the regular word list ($r=0.472$, $p_{2\text{-tail}}<0.01$) and the irregular word list ($r=0.377$, $p_{2\text{-tail}}<0.05$). Neither of the correlation coefficients for the unprimed condition were significant.

	SCHONELL SCORE	
	Irregular list	**Regular list**
Condition	e.g. 'climb'	e.g. 'bunch'
Primed	0.377*	0.472**
Unprimed	-0.095	-0.017

TABLE 8-16. Correlations between scores on the Schonell spelling test and the number of nonwords spelt 'ed' in each condition (N=32) (*$p_{2\text{-tail}}<0.05$, **$p_{2\text{-tail}}<0.01$)

Analysis was carried out for each type of word frequency: non-morphemic frequency, morphemic frequency and lexical frequency. In each case, high frequency endings were compared to low frequency endings, and noun context presentations were compared to verb context presentations. They are related to the hypotheses in Section 8.2.1.

8.3.1 Non-morphemic frequency effect

Table 8-17 shows the mean percentage of nonword endings spelt 'ed', for endings with high and low non-morphemic frequency, and in each presentation condition. In this table, 'n' represents the number of nonword stimuli in each frequency group.

High frequency (n=19)		Low frequency (n=21)	
Verb	Noun	Verb	Noun
54.1 (25.8)	30.9 (23.7)	45.1 (25.6)	29.2 (20.2)

TABLE 8-17. The percentage of nonword endings spelt 'ed'
(standard deviations in brackets)

Because the standard deviations appeared quite high relative to the means, an arcsin transformation was carried out in order to stabilise the variance (Winer, 1971, p. 400). A 2 x 2 analysis of variance was carried out on the transformed data, where the two independent within-subject variables were non-morphemic frequency (high vs. low) and context (verb vs. noun). More nonword endings were spelt 'ed' when presented in a verb context than when presented in a noun context ($F(1,31)=39.0$, $p<0.001$), confirming Hypothesis (a). Also, more nonword endings were spelt 'ed' when the endings were of high non-morphemic frequency ($F(1,31)=5.4$, $p<0.05$). This result was in the opposite direction to that predicted by Hypothesis (b). There was also a significant interaction between the effect of non-morphemic frequency and the effect of context ($F(1,31)=4.8$, $p<0.05$), which showed that the verb-noun effect (the 'priming' effect) was larger for the high frequency endings than for the low frequency endings.

8.3.2 Morphemic frequency effect

Table 8-18 shows the mean percentage of nonword endings spelt 'ed', for endings with high and low morphemic frequency, and in each presentation condition, where 'n' represents the number of nonword stimuli in each frequency group.

High frequency (n=20)		Low frequency (n=20)	
Verb	Noun	Verb	Noun
52.3 (25.4)	31.3 (23.8)	46.4 (26.0)	28.8 (20.3)

TABLE 8-18. The percentage of nonword endings spelt 'ed' (standard deviations in brackets)

These results are very similar to those for non-morphemic frequency, and, again, an arcsin transformation was carried out on the data prior to analysis. A 2 x 2 ANOVA showed that, as before, there was a main effect of context ($F(1,31)=38.2$, $p<0.001$), again confirming Hypothesis (a): nonword endings were more often spelt 'ed' when they were presented as verbs than when they were presented as nouns, this being the 'priming' effect of context. Although there was a trend towards high frequency endings being spelt 'ed' more often than low frequency endings, this was not significant ($F(1,31)=2.8$, n.s.), thus Hypothesis (c) was not confirmed. There was no interaction between the context and frequency ($F(1,31)=1.3$, n.s.).

8.3.3 Lexical frequency effect

Table 8-19 shows the mean percentage of nonword endings spelt 'ed', for endings with high and low lexical frequency, and in each presentation condition.

High frequency (n=24)		Low frequency (n=16)	
Verb	Noun	Verb	Noun
52.6 (25.5)	30.9 (23.2)	44.5 (25.8)	28.7 (20.3)

TABLE 8-19. The percentage of nonword endings spelt 'ed' (standard deviations in brackets)

Again, the results are very similar to those for non-morphemic frequency. An arcsin transformation was carried out on the data and a 2 x 2 ANOVA carried out on the transformed data. There was a main effect of context ($F(1,31)=36.7$, $p<0.001$), showing that more 'ed' spellings are used in the verb condition than in the noun condition (confirming Hypothesis (a)), and a main effect of lexical frequency ($F(1,31)=4.3$, $p<0.05$), showing that nonword endings with high lexical frequency are more likely to be spelt 'ed' than those with low lexical frequency. This result confirmed Hypothesis (d). The interaction between the effects of context and lexical frequency approached but failed to reach significance ($F(1,31)=3.3$, n.s.).

8.4 Discussion

This experiment examined the effect of a priming context on children's use of a morpheme in nonword spelling, and also examined three possible word frequency effects: that of non-morphemic frequency, morphemic frequency and lexical frequency. A single set of nonwords ending in the phoneme /d/ was presented in both a verb and a noun context. This set of nonwords was subjected to three analyses in respect of the three types of word frequency. For each analysis they were divided into high frequency endings and low frequency endings.

For all three types of word frequency, it was found that more nonword endings were spelt using the morpheme 'ed' when presented in the verb condition than when presented in the noun condition. For example, when the nonword /grɔːd/ (rhymes with 'cord') was presented in the sentence, 'The girl /grɔːd/ her homework', the nonword was more likely to be spelt 'grored' than when it was presented in the sentence, 'Someone helped me with the /grɔːd/', where it was more likely to be spelt 'grord' or 'grorde'. This was expected, and is consistent with both the findings in Chapter 7 and the apparent priming effect in Campbell and Wright's data described above. We can therefore conclude that syntactic context can prime a morpheme for use in spelling a nonword, in both adults and children.

The non-morphemic frequency of a nonword ending was expected to have a negative effect on the use of a morpheme. That is to say, if a nonword had many rhyming real words which were not past participles (e.g. /deid/ - rhymes with 'aid', 'blade', 'raid' etc.), the non-morphemic spelling would be more likely for the terminal phoneme (e.g. /deid/

would be spelt 'daid' or 'dade'). However, the opposite effect occurred in this experiment, with nonwords with a high number of non-morphemic rhymes being more likely to be spelt with a morphemic spelling (e.g. /deid/ spelt 'dayed'). This contradicts the explanation given above for Campbell and Wright's data.

One reason for this result could have been that the nonword endings which were categorised as having high or low non-morphemic frequency may have been similar in another respect. For the third type of word frequency, lexical frequency, the high and low frequency groups were practically identical to the nonword endings in the non-morphemic frequency groups. The effect of lexical frequency was significant, however, which means that the effect of non-morphemic frequency may have actually been an effect of lexical frequency instead. This is because the high and low frequency groups contained exactly the same nonword endings for non-morphemic frequency and lexical frequency except for one ending, /oud/ (rhymes with 'toad' and 'mowed'), which was in the high frequency group for lexical frequency, but in the low frequency group for non-morphemic frequency.

There was no significant effect of morphemic frequency, although the results were in the direction expected. The nonword endings which had a high number of rhyming past participles (e.g. /faid/ - rhymes with 'cried', 'died', 'fried' etc.) tended to be more likely to be spelt with the morpheme 'ed' (e.g. 'fied' or 'fyed') than those with a lower number of rhyming past participles. If this effect had been significant, we could possibly have suggested that the lexicon contains derivatives of words, e.g. past-participles, and that the spellings of these compete with non-morphemic spellings in processing nonwords. However, further studies are needed to establish the representation of information in the lexicon.

The only significant word frequency effect which was in the direction expected was the effect of lexical frequency. Here it was found that where there was a high number of real words ending in the phoneme which preceded the terminal phoneme /d/, the nonword ending would be more likely to be spelt with the morpheme 'ed'. It is proposed that the reason for this is that children add a morphemic ending if they think there is a plausible spelling for the 'stem'. Here, the 'stem' does not necessarily have to be similar to real verbs, only to a real word. This may be more valid for a child since some verbs may be derived from a noun anyway (e.g. 'snowed'). Where there are many real words, verbs and non-verbs, with the same phonemic ending as the possible nonword 'stem', then a morphemic ending is more feasible.

This suggests that the use of a morpheme in nonword spelling is partly determined by the structure of the nonword segment which precedes the morpheme. The more this resembles a possible stem, i.e. by ending in a phoneme which commonly occurs at the end of real words, the more likely it is that a morpheme will be used. Therefore we can conclude that the selection of a morpheme is not only influenced by the syntactic context in which the morpheme occurs, but also the phonetic context in which it occurs. The effect of phonetic context appears to be insensitive to the syntax of the preceding phoneme since its use depended on the frequency of the preceding phoneme as it occurred at the end of all words, rather than only at the end of verb stems (as measured by morphemic frequency). The emphasis appeared to be on producing a nonword 'stem' which was orthographically plausible, and which may be concatenated with the morpheme.

8.5 Conclusions

This experiment shows that children, like the adults in the experiment in Chapter 7, can use morphemes in spelling nonwords. Also like the adults, children's use of a morpheme is sensitive to the syntactic context in which the nonword is presented. An additional finding in this chapter was that the selection of a morpheme was sensitive to the lexical frequency of the preceding phoneme. Thus we may conclude that nonword spelling may not be a purely non-lexical phoneme-grapheme mapping process, but may use morphemes stored in the lexicon. As in adults, morphemic information may be activated by syntactic context, and in addition to this, its use may be dependent on a plausible nonword 'stem'.

CHAPTER 9

Conclusions

9.1 Overview of the thesis

This thesis has been concerned with the cognitive processes underlying spelling. Most previous research into this area has been carried out within the framework of the dual-route model, which consists of two independent processes: the lexical route and the non-lexical route. This model has been used to explain children's spelling difficulties by categorising the predominant kind of error made by a child, and classifying the child's difficulties on this basis. Errors are usually described as 'phonetic' or 'non-phonetic'. Phonetic errors are explained in terms of a faulty lexical route, causing the child to over-rely on the non-lexical route. Non-phonetic errors are thought to arise from both the lexical and non-lexical routes being faulty. However, the dual-route model cannot explain how a non-phonetic error is generated. The aim of the first half of this thesis was to find some way of explaining how children with spelling difficulties generate non-phonetic spellings.

Recent research had shown that when nonwords are spelt by adults, one part of the non-lexical process was the selection of the most common English spelling for individual phonemes within the nonword, using phoneme-grapheme mappings. The phoneme-grapheme mapping with highest English frequency in their phoneme-grapheme grammar was referred to as the mapping with 'highest contingency'. It was thought that these adults may have derived their phoneme-grapheme mappings and the relative frequencies of each from their store of spellings in the lexicon, rather than having learnt them explicitly. On this basis it was suggested that children's phoneme-grapheme mappings may also have been derived from the spellings in their lexicon. However, since they were beginning to read, it was possible that these spellings would either not contain a representative subset of English phoneme-grapheme mappings, or possibly contain mis-spellings, such that any phoneme-grapheme grammar derived from them would not be the same as English phoneme-grapheme mappings. Thus, any use of these non-lexical phoneme-grapheme mappings, e.g. in spelling nonwords, or unknown real words, would result in non-phonetic spellings. Although these would be non-phonetic, they would be rational, given that the child's phoneme-grapheme grammar contained these mappings. By getting children with spelling difficulties to spell nonwords and real words containing the same vowel graphemes, the first study (described in Chapter 3) showed that the graphemes used in the nonwords were those which occurred most often in the real words. Thus it was concluded that non-lexical phoneme-grapheme grammars are derived from spellings contained in the lexicon, and that original mis-spellings in the lexicon may account for subsequent non-phonetic spellings in nonwords.

From this study it also appeared that children with spelling difficulties did not always use the same grapheme when spelling a particular phoneme more than once. A same vowel phoneme was only presented twice, though, so it was not possible to see how consistent each child was in their selection of a particular grapheme. Another study was therefore devised to examine how consistently the highest contingency phoneme-grapheme mapping was used. In this study (described in Chapter 4), children with spelling difficulties and a control group, matched for age and sex, spelt the same vowel phoneme in up to 10 different nonwords. It was found that the children with and without spelling difficulties were equally consistent in their use of the highest contingency phoneme-grapheme mapping. In addition to this, it was found that the phoneme-grapheme mappings of the children with spelling difficulties were found to be less like English phoneme-grapheme mappings than those of the control group. Thus it was concluded that the nature of a child's phoneme-grapheme mappings may be a source of spelling difficulties.

Although the study in Chapter 4 collected up to 10 spellings of each vowel phoneme, this was not enough to be able to diagnose specific difficulties that an individual child may have with particular phonemes. It was thought that in order to identify specific problems, more data must be collected for individual phonemes. By collecting a corpus of data in which each phoneme was spelt in at least 170 nonwords, the third study (reported in Chapter 5) describes the phoneme-grapheme grammars of three children with spelling difficulties. From their data their problems with specific phonemes could be identified, and their sensitivity to the position of a phoneme in a nonword could be highlighted.

The first three studies therefore showed that children with spelling difficulties have faulty phoneme-grapheme mappings which may be identified by the graphemes they use to spell nonwords. It also appeared that, as well as non-lexical information, lexical information in the form of morphemes (word stems and affixes) was being used to spell nonwords. Most research which has been carried out within the dual-route model has so far assumed that nonword spelling is a non-lexical process which makes use of phoneme-grapheme mappings only. If it could be shown that morphemes can be used in nonword spelling, this would suggest that the lexical and non-lexical routes may actually interact. Furthermore, some morphemes do not have a strictly phonetic spelling because their function is to convey syntactic rather than phonetic information. If these morphemes are used to spell nonwords, the resulting spellings may be non-phonetic. On this basis, the aim of the second half of the thesis was to establish whether morphemes could be used in nonword spelling.

The first stage in nonword spelling is the segmentation of a nonword into its constituent phonemes. For a morpheme in the lexicon to be used, it is first necessary that the morpheme is activated by an individual phoneme. Using a phoneme-classification task, in which adults categorized the terminal phoneme in real words and nonwords, it was shown that a morpheme could be activated by a phoneme which represents a common pronunciation of that morpheme. This experiment was described in Chapter 6.

Having established that a morpheme could be activated, an experiment was carried out to see if a morpheme could be used in nonword spelling by adults. Chapter 7 described how adults were presented with nonwords ending in possible pronunciations of a morpheme. These were presented in two syntactic contexts, one of which was expected to prime the use of the morpheme. It was found that adults could use a morphemic spelling in preference to a phonetic spelling (from the phoneme-grapheme mappings) and that use of a morphemic spelling was primed by the syntactic context in which the nonword was presented. The effect of higher level information (i.e. context) in the spelling of a nonword suggests additionally that the cognitive system may be involved in nonword spelling, as well as lexical information and phoneme-grapheme mappings.

The final experiment was carried out to see if the same use of morphemes could be made by children. The experiment reported in Chapter 8 used a similar design in which children spelt nonwords ending in possible pronunciations of a morpheme, and in which these nonwords were presented in a priming and a non-priming context. As with the adults, it was found that children could use morphemes in nonword spelling and that this was primed by the context in which the nonword was presented. It was also found that children who scored more on a standardized spelling test were more sensitive to this priming effect.

These three experiments show how lexical information may be used in the spelling of nonwords by both adults and children. From this, it is concluded that the dual-route model should allow for interaction between the lexical and non-lexical routes, and that the classification of children's spelling difficulties should therefore be based on an interactive model of spelling.

9.2 Implications

One application of this work is in the testing of children's spelling ability. At the moment, spelling ability is mainly assessed in terms of quantitative measures of how many words in a particular battery a child can spell correctly. The work in this thesis suggests that although this method assesses lexical recall, it does not take into account the specific skills involved. The first three studies showed that nonword spelling could be used to identify specific phonemes which children may have difficulty with. The presentation of phonemes in different positions within nonwords may also be used to assess whether a child is aware of the different spellings of particular sounds when they occur in initial, medial and terminal positions. Thus nonword batteries may be used in remediation to identify specific areas of difficulty.

Children may also be tested on their use of morphemes in nonword spelling. In Chapter 8, the use of morphemes in a primed condition was shown to be related to general spelling ability; therefore a test schedule could include nonwords presented in priming and non-priming contexts. Children who are less sensitive to the priming effect on the use of morphemes could be introduced to these higher levels of information formally, since they have not been able to pick them up implicitly.

The interaction between lexical and non-lexical routes may also be used to diagnose writing difficulties in the study of adults with acquired dysgraphias. Research in the area of cognitive neuro-psychology frequently examines individual cases in terms of impairment to either the lexical or non-lexical route, using irregularly spelt words and nonwords respectively. However, it is possible that in some of these patients the interaction between the two routes may be impaired. This would be the case if no priming effect was shown in the spellings of nonwords in a priming context.

9.3 Limitations

The first three studies in this thesis were carried out with children with spelling difficulties. However, for each of these studies, a different criterion was used to judge the subjects' difficulties. In the first and second studies (reported in Chapters 3 and 4), the children were selected from a reading unit which they attended because they had been classified as having specific literacy difficulties by their local education authority. In the third study (reported in Chapter 5), children were selected from the study on the basis that their class teachers had identified them as having problems with spelling. It would have been better if a single criterion had been adopted throughout the thesis, and if reading and spelling ages (measured on the same scales) had been taken for all children.

A similar inconsistency occurred in the three experiments investigating priming of morphemes (reported in Chapters 6, 7 and 8). The first experiment (the phoneme-classification task) was carried out with adults. The reason for this was that the experiment was designed to test a hypothesis about the dual-route model of spelling. Since it was not testing a hypothesis about how children perform on a specific task, adults were used rather than children. The following experiment differed in terms of both the task (nonword spelling rather than phoneme-classification) and the morpheme being studied (the past participle morpheme 'ed' rather than the plural noun morpheme 's'). A more consistent investigation would have examined both morphemes in both the phoneme-classification task and the nonword spelling task.

In the final experiment, children were shown to be sensitive to priming in their use of morphemes in nonword spelling. It was also found that their use of morphemes in a priming context was directly related to their spelling ability. Again, it is not possible to compare these results with the previous study because firstly the design was very different, and secondly, different morphemes were used. It would have been better if a comparative experiment could have been used which did not rely solely on correlations to establish the value of morphemic spelling, i.e. if the children had been grouped according to spelling ability and the mean scores compared.

9.4 Further research

If morphemic spellings are to be used in spelling assessment, standardized scores need to be available for comparison. These may be obtained from a battery of data collected from children in a range of ages, as for the Schonell spelling test. The test data could focus on several morphemes, presenting them in both primed and unprimed conditions. As with the Schonell test, the standardized scores should be tabulated separately for boys and girls. These scores would denote how often morphemic spellings are used when presented in different contexts.

Research in the area of nonword spelling could be extended to investigate the relationship between the different type of frequency measures used in Chapter 8, and the priming effect of context, since the analysis revealed unexpected interaction. Research in this area could also look at the use of other morphemes in nonword spelling, such as word stems. In Chapter 4 it was reported that some children appeared to use word stems, spelling the nonword /tu:d/ (rhymes with 'food') as 'twoed', and the nonword /deid/ (rhymes with 'made') as 'dayed'. The use of lexical items in spelling, or 'lexical parsing', has already been noted by Campbell (1985), although Barry and Seymour (1988) failed to replicate any lexical parsing effects in their experiment. However, a controlled experiment could be carried out in which the effects of lexical parsing were primed in one of the conditions. This would be done by presenting the nonword in a context which is semantically related to a possible prime word. Seymour and Dargie (in press) have already shown that words in the lexicon can be activated by semantically related words (e.g. 'pope' can be activated by hearing the word 'vatican'), and that the activated word can then prime a grapheme for use in a subsequently heard nonword. Thus, presenting a nonword in a particular semantic context might activate a word which is then used in the nonword. The materials would have to include irregularly spelt words, such as 'yacht', so that if the word is used in a nonword, it could be certain that that word had been used, and that the stimulus nonword had not just been spelt out phonetically. The word 'yacht', for example, could be presented in the nonword /yɔtəd/ (rhymes with 'slotted'). This experiment could control for both semantic and syntactic priming effects on the nonword spelling. For example, a sentence which contains both semantic and syntactic priming would be 'The sailor /yɔtəd/ around the harbour', where both the word stem 'yacht' and the past participle morpheme 'ed' may be activated, to produce the spelling 'yachted'. A sentence which contained only syntactic priming, such as 'When I got home, I found that the house had been /yɔtəd/', would only activate the morpheme 'ed' and may be expected to yield a spelling such as 'yotted'. Here the stem would have been spelt phonetically but the morpheme 'ed' would have been used on the end. A control sentence would contain neither semantic nor syntactic priming, for example, 'He pulled the /yɔtəd/ onto his head'. Here it may be expected that the nonword would be spelt entirely phonetically, as 'yotid' or 'yottid'. Such use of lexical information in both semantically and syntactically priming conditions would lend support for an interactive model of spelling in which two additional levels of information were shown to influence nonword spelling, rather than just the syntactic level as shown in this thesis.

9.5 Summary

This thesis has investigated strategies used in nonword spelling by children with and without spelling difficulties and by adults. It has shown that, whereas the dual-route model of spelling expects nonwords to be spelt using a non-lexical route only, lexical information in the form of morphemes can also be used. In addition to this, higher level information about the syntactic status of a nonword may influence the use of morphemes in nonword spelling. It is recommended that future research into spelling be based on a modified, interactive dual-route model.

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Appendices

Appendix A

Phonetic symbols

This appendix lists the phonetic symbols used in the thesis. The symbols used are based on those of Jones (1972). Two vowel phonemes have been added: the dipthongs /ɔi/ as in 'boy', and /au/ as in 'cow'.

CONSONANT PHONEMES		VOWEL PHONEMES	
Symbol	**Example**	**Symbol**	**Example**
b	boat	ɑː	father
d	day	ai	fly
ð	then	æ	hat
f	foot	ʌ	cup
g	go	e	get
h	hard	ei	day
j	yes	ɛ	fair
k	cold	əː	bird
l	leaf	ə	china
m	make	iː	see
n	no	i	it
ŋ	long	ou	go
p	pay	ɔː	saw
r	red	ɔ	hot
s	sun	ɔi	boy
ʃ	show	au	cow
t	tea	uː	food
θ	thin	u	good
v	vain		
w	wine		
z	zeal		
ʒ	measure		

Appendix B

Phoneme-grapheme mappings in medial position

This appendix lists the words used to provide a count of phoneme-grapheme mappings in English where the vowel phoneme occurs in medial position.

/ei/

'a_e'

babe bade bake bale bane base baste bathe blade blame blaze brace brake brave cage cake came cane cape case cave chafe change chase chaste crane crate crave craze dale dame date Dave daze drake drape face fade fake fame fate fave flake flame frame gale game gape gate gave gaze glade glaze grace grade grange grape grave graze haste hate haze jade Jake Jane jape kale Kate knave lace lake lame lane late lathe laze mace made make male mane mate maze name nape pace page pale pane paste pate pave phase place plate quake race rage rake range rape rate rave safe sage sake sale same sane sate save scale shade shake shale shame shape shave skate slate slave snake space spade spate stake stale state stave strange take tale tame tape taste trace trade vague vale wade wage wake wane waste wave whale Yale

'ai'

bail bait brail brain braise chain claim drain fail faint faith flail frail gain grail grain hail jail laid lain maid maim main nail paid pain paint plain praise quail quaint raid rail rain raise sail saint slain snail Spain sprain staid stain strain tail taint trail train vain waif wail wain waive

'a'

bass gaol

'ei'

beige feign freight reign

'e_e'

crepe fete

'au'

gauge

'ea'

great

'eigh'

weight

'aigh'

straight

/i:/

'ea'

beach bead beak beam bean beast beat bleach bleak bleat breach bream breathe cease cheap cheat clean cleave creak cream crease deal dean dream feat freak gleam glean grease heal heap heat heath heave Jean knead lead leaf league lean leap lease leash leave mead meal mean meat neat peace peach peak peat plead please pleat preach reach read real ream reap seal seat sheaf sheath sheathe sneak speak squeak squeal steal steam streak stream teach teak teal team tease teat treat tweak veal weave wheat zeal

'ee'

beef been beep bleed breed breeze cheek cheep cheese creed creep deed deem deep feed feel feet fleece fleet freeze geese Greece greed green greet heed heel jeep keel keen keep kneel leech leek meek meet need neep peek peel peep preen queen reed reek reel seed seek seem seen seep seethe sheen sheep sheet sleek sleep sleet sleeve sneeze speech speed squeeze steed steep street teeth teethe tweet weed week weep wheel wheeze

'ie'

brief chief field fiend grieve niece piece priest siege thief thieve

'i_e'

clique niche piste quiche

'e_e'

Crete Pete scene scheme Steve theme these

'ei'

Keith seize

/ai/

'i_e'

bide bike bile bite bride brine chide chime chive Clive crime dice dime dine dive drive file fine five glide grime gripe guide guile guise hike hive jibe jive kite knife lice life like lime line mile mime Mike lithe live mice mine nice Nile nine pike pile pine pipe price pride prime prize quite Rhine rice ride rife ripe rise shine shrine side sine site size skive slice slide slime snide snipe spice spike spine spite splice sprite stile stride strike stripe strive thine thrice thrive tide tile time tripe trite twice twine vice vile vine while whine white wide wife wine wipe wise write writhe

'i'

bind climb hind kind mild mind pint rind sign wind

'igh'

blight bright fight flight fright light might night plight right sight slight tight

'y_e'

Clyde dyke rhyme scythe style thyme type

'ia'

dial phial trial

'eigh'

height

/ou/

'o_e'

bloke bode bone brogue broke choke chose chrome clone close clothe clove code Coke cone cope cove dole dome dope dose dote doze drone drove froze gnome grope grove hole home hope hose joke lobe lone lope mode mole mope node nose note phone poke pole pope pose prose quote robe rogue rope rose rote rove scope role shrove slope smoke sole spoke stoke stole stone stove strode stroke strove those tone tote trove vole vote whole woke wove wrote

'oa'

bloat boast boat cloak coach coal coast coat croak float foal foam gloat goad goal goan goat Joan load loaf loan loathe moan moat poach road roam roast shoal soak soap stoat throat toad

'ow'

blown bowl flown grown growth known shown sown

'o'

bold both cold comb fold folk ghost gross hold host knoll most poll post roll sold told toll troll yolk

'oo'

brooch

'au'

mauve

'ou'

mould soul

'ew'

sewn

/u:/

'oo'

boom boost boot booth booze brood broom choose cool coop coot croon doom drool droop food fool gloom goose groom groove hoof hoop hoot hoove loom loop loose loot mood moon moose noon noose pool roof room root school shoot smooch snoop snooze soon soothe spool spoon stooge stool stoop tool toot tooth troop whoop whoosh zoom

'u_e'

brute crude cute duke dune dupe fluke flute fuse huge Jude juke June mule muse mute nude plume prude prune rude rule ruse spruce truce tube tune

'ui'

bruise cruise fruit juice sluice suit

'ou'

ghoul group douche route soup wound youth

'ew'

jewel news newt shrewd strewn

'o_e'

lose move prove whose

'u'

Ruth truth

'eu'

feud sleuth

'o'

tomb womb

'ue'

duel fuel

Appendix C

Phoneme-grapheme mappings in initial and terminal position

This appendix lists the words used in a count of phoneme-grapheme mappings for vowel phonemes occurring in initial and terminal positions in monosyllabic words. The graphemes shown in bold print are the most common graphemes for a phoneme.

Phoneme	Position	Grapheme	Words
/ei/	**Initial**	**a_e**	ache age ale ape ace ate
		ai	aid ail aim
	Terminal	**ay**	bay bray Kay clay day Fay flay fray gay gray hay Jay lay May may pay play pray ray say slay stay sway stray tray way
		ey	grey prey they
		eigh	neigh sleigh weigh
/i:/	**Initial**	**ea**	East eat ease each
		e_e	eke eve
		ee	eel
	Terminal	**ee**	bee fee gree glee Lee knee see tee tree twee three
		e	he me we she the
		ea	flea pea plea sea tea
		ey	key
		i	ski
/ai/	**Initial**	**i_e**	isle ice
	Terminal	**y**	cry dry fly fry my ply pry sky sly spy sty try why shy thy
		ie	die lie pie tie vie
		igh	high nigh sigh thigh
		uy	buy guy
		ye	bye rye
		i	hi

/ou/	**Initial**	**oa**	oak oaf oat
		o_e	ode
		ow	own
	Terminal	**ow**	bow blow crow flow glow grow low mow row sow slow snow stow tow show throw
		oe	doe foe hoe Joe roe toe woe
		o	go no so
		ew	sew
/u:/	**Initial**	**oo**	ooze oof
	Terminal	**ew**	brew crew drew flew grew Jew new few dew pew stew screw shrew threw chew view
		ue	blue clue glue hue rue sue true cue
		o	do who two to
		oo	boo coo too zoo
		oe	shoe
		ou	you
		ough	through

Appendix D

A block of nonwords

This appendix lists an example of one of the blocks of nonwords used in the study in Chapter 5. The capitalized letters represent the vowel phonemes. Instead of a phonetic notation for these, letter names are used. These correspond to the following vowel phonemes: A is pronounced /ei/, E is pronounced /iː/, I is pronounced /ai/, O is pronounced /ou/ and U is pronounced /uː/.

kOf wEs vUdz kIk wOs gE zIv nAn rEz mOb gAf dOn yIdz dzUv kIz dAg dzIn lOk tIg wOf pEdz sAd pOg lEl zIt kOg pUb kOdz An bUs zAd dzUf gIs nUp zA vOz zIm vUn nAg rUb dzIl tUs dzId lUl dIf gUd kIs gEm wAp sIdz yEb dzUg kIm vU yOg kEt bAf kUv sOt yEd dUv sAg dzEt fUdz kIn dUt gOv rEg Ip vEd tAg zUs vOn pEf sUk gEv zO vUs lAf rIb nEv sOm fUg yAt zUg mIdz Eg tAd pOv zUdz gOb Udz gOf pAp dzEf pAm yUb kIf fEk lOs bIv zOdz fAb nUm dEf vUp nOdz zAv yOm nAs gIdz pUv yEt tOb gEp yIs fOf wIdz dAs hUk fIp gEg zIf Edz nAt pOdz mIv bOk dzUdz Ol pId tOk mUp Eb wUf zIk kUs nEn wIb yEn gUb bIdz tAv

Appendix E

The response sheet

Shown below is an example of the response sheet which was used in the experiment in Chapter 6.

1	s	z	21	s	z	41	s	z
2	s	z	22	s	z	42	s	z
3	s	z	23	s	z	43	s	z
4	s	z	24	s	z	44	s	z
5	s	z	25	s	z	45	s	z
6	s	z	26	s	z	46	s	z
7	s	z	27	s	z	47	s	z
8	s	z	28	s	z	48	s	z
9	s	z	29	s	z	49	s	z
10	s	z	30	s	z	50	s	z
11	s	z	31	s	z	51	s	z
12	s	z	32	s	z	52	s	z
13	s	z	33	s	z	53	s	z
14	s	z	34	s	z	54	s	z
15	s	z	35	s	z	55	s	z
16	s	z	36	s	z	56	s	z
17	s	z	37	s	z	57	s	z
18	s	z	38	s	z	58	s	z
19	s	z	39	s	z	59	s	z
20	s	z	40	s	z	60	s	z

1	s	z	21	s	z	41	s	z
2	s	z	22	s	z	42	s	z
3	s	z	23	s	z	43	s	z
4	s	z	24	s	z	44	s	z
5	s	z	25	s	z	45	s	z
6	s	z	26	s	z	46	s	z
7	s	z	27	s	z	47	s	z
8	s	z	28	s	z	48	s	z
9	s	z	29	s	z	49	s	z
10	s	z	30	s	z	50	s	z
11	s	z	31	s	z	51	s	z
12	s	z	32	s	z	52	s	z
13	s	z	33	s	z	53	s	z
14	s	z	34	s	z	54	s	z
15	s	z	35	s	z	55	s	z
16	s	z	36	s	z	56	s	z
17	s	z	37	s	z	57	s	z
18	s	z	38	s	z	58	s	z
19	s	z	39	s	z	59	s	z
20	s	z	40	s	z	60	s	z

Appendix F

Non-morphemic frequency of word endings

This appendix lists the words ending in phoneme clusters which were used to assess non-morphemic competition in the experiment in Chapter 7.

/nd/ and end band bend bond bind bound bland blend blond(e) blind brand kind fond fund fiend find found frond friend gland grand grind ground hand hind hound land lend mend mind mound pond pound rand rind round sand send sound spend stand strand tend trend wind wand wind wound wound

/ld/ old build bold bald cold field fold guild gold held hold mild mould sold told child weld wild wield shield

[vowel] + /d/

aid bade blade braid fade grade spade trade maid raid wade shade made bride guide glide pride side slide hide ride wide board broad cord ford fraud hoard lord ward brood crude food modd rude shrewd code toad load mode road bird word third herd cloud proud loud crowd card guard hard void

/kt/ act fact pact tact sect

/ft/ lift left loft raft rift sift soft waft weft gift deft daft cleft craft croft swift tuft theft thrift shaft shift shrift

/pt/ apt opt kept crypt leapt rapt swept wept slept

/st/ best baste beast boast boost burst bust blast breast cast cost caste coast crust crest Christ quest dust fast fist feast first foist frost guest ghost haste host hoist just joust last lest list lost lust least mast most moist past past paste piste post rest wrist rust roast cyst test taste toast tryst trust twist chest chaste vast vest west whist waste worst thrust

/dəd/ splendid candid sordid

/təd/ fœtid

Appendix G

Stimulus list A

The first list of stimulus sentences, List A, used in the experiment in Chapter 8 is shown below. The nonword in each sentence is underlined. Sentences in **bold** are those in which the nonword is presented as a noun. Sentences in *italic* are those in which the nonword is presented as a verb. Sentences in normal font are the 'filler' sentences.

Police inspected the glern

The children slord in the playground

A dripe occurred at last

My dog chewed up the skoid

A grell was stuck in the pipe

The boy snerd all day long

I was wearing an expensive blenk

Dad bought a nide in the shopping centre

A fanch counts as two points

My sister blard a nail into the wall

We mended the preel at the weekend

She ate a whole krade on her own

We kept our eyes on the groon

The fox dade away from the dogs

A broze entered the room

The computer was left on the drerd

I poured glerp all over my chips

An old man stide his pension

Our lawn was sprinkled with grorze

The froud was seen by a number of people

Dad helped me with my blize

Susan hoid her dress on the door handle

We threw the pilch in the air

I was given a shiny new snard

We played darp at the leisure centre

A river fode its way through the valley

Give me back my nerp!

The tude kept us awake at night

My bike needs a new snook

The car skade under the bridge

A prule exploded in the distance

The blide appeared to be shaking

A light plane landed on the choop

The fish moid along the river bed

A man carried the derk

We poured some kroid into a jar

I had to talk all day to the droon!

The girl grord her homework

A gleep swam across the lake

Someone had buried the frude

A cratch attached itself to my foot

The ship trord across the ocean

A browk was found in my tooth

The children had to water the bloud

My prern gave me a lift home

A stranger flerd along the street

I badly needed a new groll

We always have a dode for breakfast

A preet hid the animals

The heavy rain grard down the roof

My feet were completely trife

I drank a plude of orange juice

Nobody saw them take my stope

The gardener spoud in the greenhouse

All the noosh had gone by nighttime

My mum made a plode

The glark came on television

My friend klerd her computer

A drail fell to Earth

I needed to have my own krord

We put the krorn in a wheelbarrow

The horse blord over the jump

I couldn't reach the froob in time

For my birthday I was given a huge groud

A finny had been left on the table

My sister skode all day with her friends

The children travelled home in a flitch

Someone took my fide without asking me

A dreeb usually grows in Spring

The doctor plard at the patient

We were told to search for a bresh

My hade was discovered in the playground

The man left his glerk on the coat hook

Our neighbour slude under his car

Mum made me clean the losh

We listened carefully to the brode

The proop couldn't wait to get home

A lorry gride another load

I ate another werve

We were all surprised to see a tade

Appendix H

Stimulus list B

The second list of stimulus sentences, List B, used in the experiment in Chapter 8, is shown below. The nonword in each sentence is underlined. Sentences in **bold** are those in which the nonword is presented as a noun. Sentences in *italic* are those in which the nonword is presented as a verb. Sentences in normal font are 'filler' sentences.

A browk appeared on the horizon

The child skoid in the playground

Some police checked the werve

My dog chewed up the slord

A prern had clogged up the pipes

Michael nide all day long

I was wearing a beautiful groll

Dad bought a snerd in the shopping centre

A plair counts as two points

Mum krade a nail into the wall

We mended the trife at the weekend

She ate a whole blard on her own

We were warned about the noosh

The badger drerd away from the dogs

A stope suddenly flew into the air

The computer was left on the dade

I poured glark all over my chips

The old man froud his pension

Drail was used to pot the plants

The stide was seen by a number of people

My dad helped me with my krorn

Susan snard her dress on the door handle

We took the flitch to the vet

I was given a shiny new hoid

We played finny at the leisure centre

A river tude its way through the valley

Give me back my froob!

The fode kept us awake at night

My bike needs a new dreeb

The sports car blide along the motorway

A bresh exploded underground

The skade appeared to be shaking

Mr. Peters landed on a glerk

The fish kroid along the river bed

A man fell into the losh

We poured some moid into a jar

Don't leave me alone with the proop!

The girl frude her homework

I got in the way of the dripe

Someone helped me with the grord

A glern attached itself to my foot

The ship bloud across the ocean

A grell got in my way

Did anyone water the trord?

The blenk offered us a lift home

A stranger dode along our street

Please may I have a new fanch?

Everyone loves a flerd in the morning

Is there a preel in the house?

The rain plude into the gutter

My toes were completely groon

I drank a grard of orange juice

All the broze had gone by nighttime

Somebody plode in front of my house

Did anyone see my glerp?

My mum made a spoud

The graws came out on video

My friend krord her computer

A blize fell to Earth

I wish I had my own klerd

We need some more pilch

The eagle groud into the air

They went home in a darp

For my birthday I was given a huge blord

A nerp was left on the table

My sister fide all day with her friends

I got a job as a snook

Someone put my skode in a basket

A prule was left out all night

The doctor hade at the patient

A choop always stays out late

My plard was found in the playground

The man left his derk on the coat hook

Our neighbour brode under his car

Mum made me clean the droon

All we could hear was a soft slude

The gleep couldn't wait to get home

A lorry tade another load

I ate yet another cratch

We were all surprised to see a gride