DOCTOR OF PHILOSOPHY

Morphological processing in dyslexic children

Egan, Joanne

Award date:
2003

Awarding institution:
University of Wales, Bangor

University of Wales
Prifysgol Cymru

Morphological Processing in Dyslexic Children

by

Joanne Egan

A Thesis is submitted to The School of Psychology, University of Wales, Bangor, in partial fulfilment of the requirements of the Degree of Doctor of Philosophy

July 2003

SUMMARY

The ability to represent and comprehend written language is an important survival skill in modern life; this is why research on reading and spelling occupies such a dominant place in cognitive psychology.

Over the past 50 years, much has been learned about the processes involved in reading and writing. Of particular interest is the question of how children learn to read and spell. So far, we know that children's ability to process the sounds in language plays a vital role in reading and spelling acquisition. In the early stages of literacy, children who are able to detect how two words sound alike are at an advantage over those with poorer phonological skills (Bradley & Bryant, 1983). This is because the ability to hear the sounds in words depends, in part, on the ability to segment a word into its constituent sounds. Segmentation skills are a vital aspect of learning to read and spell new words.

However, reading and spelling are not just about linking letters to sounds and vice versa. In languages like English and French, words are not spelled solely on the basis of sounds. Some words are spelled in a particular way because some letter strings constitute units of meaning, or morphemes. For instance, although *kissed* could be spelled *kist* on the basis of its sounds, it is actually spelled with an *–ed* ending because this denotes the past tense status of the verb. Children's understanding of morphology, therefore, plays a vital role in reading and spelling acquisition. Despite its importance, children's development of morphological awareness in relation to reading and spelling has not received the same level of attention as the role of phonological awareness.

Given that phonological awareness plays such a vital role in early literacy, it is not surprising that children who have difficulties learning to read and spell tend to have poor

phonological skills. There is a consensus in the field that developmental dyslexia, in which children with no constitutional or general cognitive impairment have extreme difficulty learning to read, is underpinned by a deficit in phonological processing. This finding has had far reaching implications for the way in which dyslexic children are taught; many remedial reading programmes place phonological awareness training at their core.

But when dyslexic children's phonological awareness improves and they are able to read and spell words on the basis of grapheme-phoneme correspondences, the majority do not go on to become fully literate; their reading may reach an adequate standard, but their spelling and writing usually remain poor. This has led some researchers to wonder whether dyslexic children have wider reaching linguistic deficits; specifically, do they have deficits in their ability to process grammatical information?

Grammar is really a portmanteau term that encompasses a range of language processing devices: word order (syntax), punctuation, and the ability to denote the appropriate status of a word so that it agrees with other words in a sentence (derivational and inflectional morphology).

This thesis focuses on how children with dyslexia process one aspect of grammar – regular past tense inflectional morphology – in relation to groups of normally developing children. Regular past tense inflectional morphology refers to the way in which the *–ed* suffix is added to verbs to place them into the past tense.

Studies reviewed in Chapter 3 show that data exist to suggest that dyslexic children are impaired in written and spoken domains of inflectional processing. However, many of these studies did not methodically compare dyslexic children to both spelling and reading age matched controls and chronological age matched controls, nor did they concurrently assess children on a range of written and spoken measures of inflectional morphological processing.

The use both chronological age and spelling and reading age control groups can be extremely informative when attempting to conclude where the source of dyslexic children's difficulty may lie. For instance, if dyslexic children are poorer than those of the same age on spoken language tasks, but similar to those with the same reading and spelling levels, the conclusion would be that the dyslexic children's spoken language performance is due to their poorer levels of literacy. However, poorer performance relative to younger children would indicate that the dyslexic children have spoken language deficits.

The studies in this thesis aim to address three main questions:

1. **Do children with dyslexia exhibit difficulties with inflectional morphology in reading, spelling or spoken language, in comparison to normally developing children?**

To address this question, a pilot study was first carried out (Chapter 4, Pilot study) comparing 12 dyslexic children (DR) aged 11 years, to chronological age (CA) and spelling and reading age matched (SA-RA) controls. The DR group was poorer at spelling regular past tense inflectional endings, but no worse at spelling the ending of one morpheme words, compared to the SA-RA group. There were no differences between the DR and SA-RA groups on spoken language measures.

In the first study (Chapter 4, Experiment 1), 28 dyslexic children aged 9 years were tested. It was found that the DR group was poorer than CAs on their reading and spelling of regular past tense inflected verbs. Relative to the SA-RA group, they were no worse at reading regular past tense inflected verbs but were a great deal poorer at spelling the regular past tense *–ed* ending. This finding occurred on two different spelling tasks, which suggests that the finding is robust, at least for the children used in this study.

2. What are the likely causes for dyslexic children's impairments in spelling of the past tense *–ed* ending?

The three groups of children from Experiment 1 were assessed on a range of written and spoken tasks. Their regular word, irregular word, and non-word reading and spelling performances were compared (Chapter 4, Experiment 2). There were no differences between the DR and SA-RA groups on any of the tasks. This suggested that their difficulties with spelling the regular past tense *–ed* ending were not related to deficiencies in orthographic knowledge or phoneme-grapheme/grapheme-phoneme conversion abilities relative to the SA-RA group.

The groups' spoken language morphological and phonological awareness was compared, and no differences emerged between the DR and SA-RA groups, other than superior performance by the DR group on one task of morphological awareness (Chapter 4, Experiment 3).. The DR group was poorer than the CA group on phonological awareness tasks, and on most of the morphological awareness tasks. This suggests that dyslexic children's difficulties on explicit spoken language tasks can perhaps be accounted for by their impoverished experience of print.

A regression analysis showed that, for all three groups, orthographic knowledge was the most important indicator in their correct spelling of the *–ed* ending. In addition, for the SA-RA group, morphological awareness also emerged as a significant predictor.

It has been found that awareness of morphology in spoken language plays a role in spelling of the *–ed* ending (Nunes, Bryant, & Bindman, 1997a). Application of morphological rules to spelling was assessed through a task in which children had to spell /t/ and /d/ sound ending non-words in either a noun or verb context (Chapter 4, Experiments 4a and 4b). While adults spelled non-word endings according to their syntactic class, the children's data revealed that none of the three school aged groups made this type of distinction. This led to the conclusion that perhaps the role of morphological awareness in spelling of the *–ed* ending is not as important as has been suggested.

The overall conclusion was that the cause of the dyslexic children's poor use of the *–ed* ending was not evident on the basis of studies carried out in Chapter 4.

3. Is there a sub-group of dyslexic children who have particular difficulties with morphological spelling?

A close look at the dyslexic group's scores in Experiments 1-4 showed that some of these children were particularly poor at using the *–ed* ending in the light of near ceiling performance on applying the correct phonetic ending to irregular verbs and one morpheme words.

The following year, a new set of dyslexic children were screened (Chapter 5) and three children were selected for case study research on the basis of their poor use of the *–ed* ending in comparison to their good use of phonetic endings on irregular verbs and one morpheme words. A further child, who over-used the *–ed* ending, was also recruited. These children were assessed on a range of morphological and phonological tasks. There was some variation of scores within this group, but the main findings were that: (a) all had morphological and phonological awareness within the normal range for their age; (b) they all had particular difficulties with irregular spelling and reading, in relation to their regular and non-word reading and spelling.

The general conclusion from the studies described in Chapters 4 and 5 is that dyslexic children do, as a group, have difficulties with spelling past tense *–ed* endings. However, this does not mean that they are deficient in inflectional morphological processing. Poor use of the *–ed* ending can occur for a number of reasons, and it is important to assess children's use of this ending in relation to their ability to spell other types of words. For those with phonological impairments, their unstable phoneme-grapheme skills can account for their problems; these children are poor at spelling most types of words and so will apply incorrect graphemes to phonemes. In addition, these children are still in the alphabetic stage of spelling development, and so cannot move on to learning spelling rules for complex phoneme-grapheme relationships.

For another group, particularly those with normal or remediated to normal phonological skills, their poor use of the *–ed* ending relates to weak orthographic skills. This latter set of children, all of whom have good morphological awareness, would particularly benefit from teaching strategies that emphasise the links between grammar and spelling, as they do not have inherent difficulties with grammar.

Before describing the experiments in depth, a review of the relevant literature is provided. Chapter 1 discusses the development of reading and spelling. In Chapter 2, the nature and causes of developmental dyslexia are outlined. In Chapter 3, the ways in which adults, normally developing children, and dyslexic children process morphologically complex words are discussed.

Acknowledgements

This PhD studentship was funded by the Econonic and Social Research Council, award no. R00429934130.

I would like to thank Marie-Josèphe Tainturier for her expert guidance and detailed supervision. I will always be indebted to her for everything she has taught me, and for the opportunities she has provided. I am also grateful to other members of the School of Psychology whose comments and suggestions have been useful, particularly Ginny Gathercole and Nick Ellis. Thanks also to the computer support team for all their assistance with IT.

I have been fortunate to have worked with some extremely supportive and helpful schools. I want to acknowledge the participation of all the teachers and children from Belgrave Infant School, Dodleston Primary School, Lache Primary School, Overleigh St Mary's Primary School, Christleton High School, Queen's Park High School, Cherry Grove Primary School, and Saltney Ferry Primary School (all in Chester); Cambridge Road Primary School and Sutton Green Primary School (all in Ellesmere Port); the Alexandra Primary School (in Wrexham); Ewloe Green and Venerable Edward-Morgan Primary School (in Flintshire), and St Gerrard's School (in Bangor). Without the enthusiastic participation of the children in these schools, none of this research would have been possible.

Last but by no means least, I would like to thank my entire family for providing me with so much practical support and encouragement. I particularly want to thank my husband, Mike, and my children, Madeleine, Francesca, and Samuel for making it all worthwhile.

Dedications

I dedicate this thesis to my mother, Jean, and my late father, Antony.

Table of Tables

Table of Figures

Table of Contents

CHAPTER 1

READING AND SPELLING DEVELOPMENT

Reading and spelling are complex skills, involving the integration of many cognitive and motor processes: visual perception, short and long-term memories, phonological recoding, and fine motor control. For skilled readers and spellers, these processes are largely automatic; they can read and spell words that conform to letter-sound rules (i.e., regular words like *carpet*), and those that do not (i.e., irregular words like *yacht*). In addition, they are able to rapidly read and write words that have no representation in their spoken language repertoire (i.e., nonwords like *molsmit*). In this chapter, theories and research concerning how skilled reading and spelling is performed will be overviewed before turning to the literature on how children reach skilled levels of literacy.

1.1 How adults read and spell

Central to the task of reading is the ability to map the symbols that make up words onto our well-developed system for language understanding. This process is referred to as word recognition, and most skilled readers can access a word's meaning and pronunciation within a fraction of a second. They can do this even when the form of the letters that make up the words vary; they can decipher a range of hand-written and typefont styles.

There are a number of ways to assess the mechanisms involved in word recognition: naming latency tasks; categorisation tasks (i.e., does a word belong in a particular category?); lexical decision tasks (i.e., is the presented item a real word or not?); and brief presentation methods. Studies using these techniques have reported that words are recognised more quickly when they are: high in familiarity (Eichelman, 1970; McCann &

Besner, 1987); high in frequency (Monsell, 1991); acquired at an early age (Coltheart, Laxon, & Keating, 1988), or presented in context (Tulving & Gold, 1963; Meyer & Schvaneveldt, 1971).

Spelling is quite error-prone compared to reading; most literate people make more spelling than reading errors. Whereas a word can be read: (a) through partial analysis of its constituent letters (e.g., *band*ge*); and (b) despite sequencing errors (e.g., *recieve; tarffic*), a word can only be spelled successfully when each letter is correctly represented and positioned. In addition, although the reading of a word with many spellings yields the same pronunciation (e.g., *there, their,* and *they're),* the auditory presentation of a word can be translated into a number of spelling options, only one of which will be correct. Despite its difficulty, many people learn to spell very well, and are able to approximate spellings for words they have never encountered. Words that cause most difficulty for skilled spellers are: those with doubled consonants at a morpheme boundary (e.g., *referred > refered*); double letters in multi-syllabic words (e.g., *accommodate > accomodate* or *acommodate*) and words containing schwa vowels (e.g., *separate > seperate*; *independent > independant*) (Brown, 1988).

1.2 Theories of reading and spelling

Broadly, there are two main theories or ideas about written word processing: dual route theories and connectionist models. Although primarily developed to account for reading, the processes they describe may be reversed to apply to spelling, with the caveat that the processes involved in spelling output are probably more fragile than those involved in reading output, due to higher demands on memory and greater phoneme-to-grapheme than grapheme-to-phoneme inconsistency.

Dual-route models

Dual-route models of reading suggest two routes from print to articulation: a direct lexical route and an indirect sub-lexical phonological route. The lexical route passes through a central, semantic system (Coltheart, 1978; Morton, 1969, 1979; Newcombe & Marshall, 1981). Early dual route models were subsequently modified to include a third reading route that bypassed semantics (Shallice, Warrington, & McCarthy, 1983), so, strictly speaking, they are better conceptualised as multiple route models (though they are rarely called this, so will be referred to as dual-route models here).

The basic model is a simple one that can readily incorporate other aspects of language processing like spelling and picture naming (see Fig. 1.1).

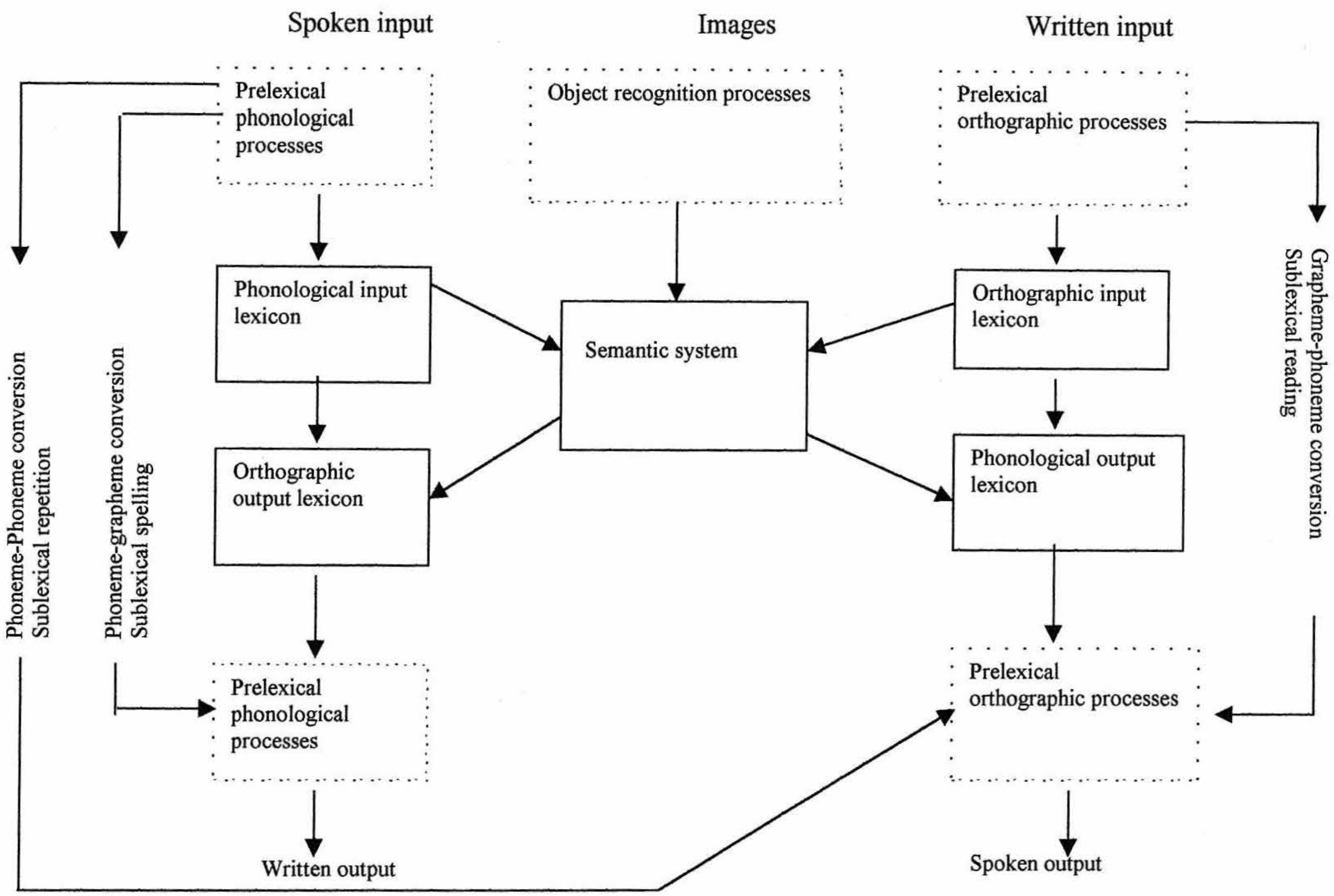

Figure 1.1. A general model of single word processing. Adapted from Tainturier and Rapp (2001)

The key property of dual-route models is their modularity: words are analysed through a system of modules, each of which is responsible for processing an aspect of the word. In the orthographic lexicons (a store of words in the sight vocabulary), each word has a threshold of activation, so a word with a high frequency is more easily activated than a word with low frequency. In most models, words are represented in the orthographic lexicons as morphemes; the way that multi-morphemic words are processed is not well specified by most general word processing models (models of how morphologically complex words are processed will be discussed in Chapter 3). The phonological lexicons contain a store of words' pronunciations.

In reading, the lexical route involves a match between printed words and those stored in the orthographic input lexicon. Printed words are analysed and information about the letters present and their relative position is provided. If enough features of the word are present, its internal representation and meaning is activated. In reading aloud, the word's pronunciation is activated through the phonological output module. In spelling, the reverse occurs. A word's pronunciation is accessed, then its meaning, and finally its spelling is located in the orthographic output lexicon (Tainturier & Rapp, 2001).

As previously mentioned, a third route, direct from the input lexicon to the output lexicon, bypassing semantics, is also available. This third route enables models to accommodate neuropsychological data of patients whose reading and spelling are preserved despite the fact that their semantic system, as assessed through picture naming, is impaired (e.g., Caramazza & Hillis, 1990; Schwartz, Saffran, & Marin, 1980).

The sub-lexical route enables readers to read aloud novel pronounceable letter strings: non-words, foreign words and new words. This route operates a system of rules specifying the relationships between letters and sounds in English; some models suggest the formulations of this system are based upon grapheme (i.e., the written representation of a phoneme) to phoneme (i.e., the smallest sound unit in spoken language) rules (e.g., Coltheart, 1978), whereas other models suggest that the conversion rules are based upon larger orthographic units such as consonant clusters, sub-syllabic units, syllables and morphemes (Shallice & McCarthy, 1985). The phonological route can produce correct pronunciation of words with regular spelling-to-sound correspondence, but will make errors on irregular words, like *pint* or *have*.

The dual-route approach is able to account for how skilled readers read exception words and non-words aloud, and how they can perform lexical decision tasks. It also accounts for neuropsychological data, such as how surface, phonological and developmental dyslexias and dysgraphias arise, by postulating impairment to either the lexical or phonological reading route. For example, in surface dyslexia, whereby patients can read non-words and regular words but make regularisation errors on irregular words (e.g., read *glove* as if it rhymes with *cove*), dual route theorists suggest that the lexical route is impaired. Conversely, for phonological dyslexia, in which non-word reading is impoverished, they postulate impairment to the phonological route.

Coltheart, Curtis, Atkins and Haller (1993) acknowledge that traditional dual-route models have two weaknesses: (a) they represent a mature system and so cannot account for development; and (b) they are modular rather than computational, so do not mirror the biological processes that occur in the brain. To address these problems, Coltheart et al. (1993) proposed a Dual-Route Cascaded Model of reading. This is still a modular system, but they propose that connectionist models of the various modules could be attempted.

Connectionist models

Connectionist models are not necessarily opposed to the notion of two routes, but traditional models have tended to favour the use of a single route in reading (McClelland and Rumelhart, 1981; Seidenberg and McClelland, 1989).

Connectionist or Parallel Distributed Processing (PDP) models of reading aloud are computer programs that accept letter strings at input and produce some form of phonological representation at output. For spelling to dictation, the reverse occurs. The Seidenberg and McClelland (1989) model has three layers: 400 orthographic units are connected to 200 hidden units (80,000 connections), and all 200 units are connected to 460 phonological units (92,000 connections). In addition, there are 80,000 connections from the hidden units back to the orthographic units. The connections initially have random weights, so that the network at first computes random pronunciations for orthographic inputs. The network trains itself, using back-propogation, and the consequent adjustments of weights produces progressively increasing accuracy of the patterns of activation across the phonological units in response to orthographic inputs.

Each of the 400 input units consists of a list of 10 possible first characters, 10 possible second characters, and 10 possible third characters. Consequently, each orthographic unit specifies 1,000 possible character triples (e.g., *mad, dem, plo*). An input string turns on an orthographic unit if that string contains three consecutive characters that is 1 of the 1,000 triples in the unit's repertoire. For example, if the input string is *made*, it will turn on any unit that includes any of the triples *#ma, mad, ade, de#*. The probability that two different input strings would activate the same set of orthographic units is practically zero.

Each of the 460 phonological output units represent a single triple; this derives from the concept of the Wickelphone; a sequence of three consecutive phonemes. Each Wickelphone corresponds to a set of Wickelfeatures, where a Wickelfeature is sequence of three phonetic features, one from each of the three consecutive phonemes of the Wickelphone.

The traditional model has been criticised, notably because of its inability to read non-words as well as adult readers (Besner, Twilley, McCann, & Seergobin, 1990) or children (Coltheart & Leahy, 1992). It was also unable to offer an account of the double dissociations within acquired dyslexias.

Because of the problems cited above, a number of multiple route connectionist models have been proposed in recent years (Plaut, McClelland, Seidenberg, & Patterson, 1996; Seidenberg, Plaut, Peterson, McClelland, & McCrae, 1994).

1.3 Reading and spelling development

Charting universal stages of literacy acquisition is difficult, because there are differences between countries in the age at which children learn to read and spell. Language differences also have an effect; apart from the obvious differences that would arise from learning a logographic script, like Japanese Kanji, there are also differences within alphabetic scripts. In German and French, where grapheme-phoneme correspondences are more transparent than English, children tend to use phonological strategies in reading from the outset and so bypass the whole word reading stage first used by their English peers (Sprenger-Charolles, Siegel, & Béchennec, 1997; Wimmer & Goswami, 1994). Within countries, the type of instruction administered will have an effect on how quickly children acquire literacy; children taught with phonic methods learn to read and spell more quickly than those who are taught by whole word methods (e.g., Lundberg, Frost, & Peterson, 1988; Wise, Olsen, & Treiman, 1990). There are also individual differences between children in their spelling and reading strategies; some rely heavily on phonological methods whereas others favour visual strategies (Baron, 1979; Treiman & Baron, 1981) – though these preferences are likely to be influenced by the type of instruction a child receives. Despite these confounding factors, theories of reading and spelling acquisition have been developed with reference to alphabetic orthographies (though they primarily relate to English).

1.4 Models of Reading and Spelling Development

A number of models of reading and spelling development have been proposed over the years; the best known of these are outlined in Tables 1.1 and 1.2. Only two of the models, those of Uta Frith (1985) and Linnea Ehri (1986, 1991, 1994, 1995), relate to both reading and spelling. Given that spelling and reading share a common knowledge base, and exert reciprocal influences on each other, combined models are perhaps a more useful and parsimonious way of interpreting data. Consequently, only the combined models of reading and spelling will be dealt with in any depth in this section.

The models of reading and spelling development in Tables 1.1 and 1.2 share common features: (a) they are based on data of children's reading and spelling errors; (b) they stress the pivotal importance of phonological awareness in literacy development; and (c) with the exception of Ehri, they postulate discrete, invariant stages of literacy development which are reached after a shift has occurred in the child's intellectual development. While these models suggest that the adoption of a new strategy for reading or spelling does not supplant an older one, they do stress that the most recently acquired strategy tends to dominate.

Although the number of stages varies from one model to another, they generally postulate that children first learn to read and spell in a logographic manner, that is, on the basis of learned associations between the visual and spoken representations of words.

Children then adopt an alphabetic decoding strategy, which allows them to decipher new words by making correspondences between letters and sounds. Finally, children master "higher order" decoding skills (i.e., complex phonological rules, morphological rules, orthographic patterns), and are eventually able to read and spell by direct lexical access.

Table 1.1. Models of Reading Development

Marsh et al (1981)	**Frith (1985)**	**Ehri (1986, 1991, 1994, 1995)**	**Strategy of stage**	**Example of responses**
Glance and guess	Logographic	Prealphabetic/ Logographic	Reading words on basis of: (a) rote learning (b) linguistic guessing.	(a) Read "boy" as "boy" (b) Read "cill"' as "woman"
Discrimination Net Guessing		Partial alphabetic/phonetic cue	Using more features of the word, such as length and shape, to aid guessing. Use of letter names.	Read "cill" as "child"
Sequential Decoding	Alphabetic	Full Alphabetic	Use of letter-sound correspondences.	Read "cill" as "kill"
Hierarchical Decoding	Orthographic	Consolidated alphabetic/ morphemic	Use of: (a) higher order rules (b) analogies.	(a) Read "cill" as /sil/ (b)Read "faugh" as /fœf/

Table 1.2. Models of spelling development

Henderson (1985)	Gentry (1982)	Ehri (1986, 1991, 1994, 1995)	Frith (1985)	Strategies of stage	Example of spelling error at this stage
Preliterate writing stage	Precommunicative stage	Prealphabetic	Logographic	Spellings as random letter strings	OPX for "giraffe"
Letter-name spelling stage	Semiphonetic stage	Parital alphabetic/ Semiphonetic stage	Alphabetic	Uses letter names for spellings	JRF for "giraffe"
Within-word pattern stage	Phonetic stage	Full alphabetic/phonetic stage		Letters assigned to spellings strictly on the basis of sound	GERAF for "giraffe" KIST for "kissed"
Syllable juncture stage	Transitional stage	Consolidated alphabetic/ morphemic stage	Orthographic	Correct use of double consonants. Correct use of suffixes.	Errors relating to: schwa vowel sounds; double consonants before suffixes; silent letters
Derivational principles	Correct stage			Spelling relations between root words are assimilated (e.g. , confident/confide/ confidential)	

Frith (1985)

Frith has proposed a three-stage, six-step model of reading and spelling development (Figure 1.2). She argued that reading and spelling develop out of step with each other, and the use of a strategy in one domain serves as a 'pacemaker' in another (Ellis, 1997).

Step	READING	SPELLING
1a	***Logographic$_1$***	(symbolic)
1b	Logographic$_2$	Logographic$_2$
2a	Logographic$_3$	***Alphabetic$_1$***
2b	Alphabetic$_2$	Alphabetic$_2$
3a	***Orthographic$_1$***	Alphabetic$_3$
3b	Orthographic$_2$	Orthographic$_2$

Figure 1.2. Frith's model of reading and spelling acquisition (strategies acting as 'pacemakers' at each step are italicised). Taken from Ellis (1997).

In her model, the first stage of literacy acquisition is logographic reading (Logographic$_1$), which in turn leads to logographic spelling (Logographic$_2$). Children continue to use the logographic route in reading, but start using the alphabetic code in spelling (Alphabetic$_1$) and this, in turn, enables them to use phonological decoding as a strategy in reading (Alphabetic$_2$). Eventually, practice at reading using phonological decoding enables children to encode larger phonological units as discrete letter sequences, for example,–*ight*. In addition, reading exposure precipitates children's awareness of orthographic conventions (such as silent letters, double consonants), which leads to the use of a direct lexical route in reading (Orthographic$_1$), though they continue to spell using a sublexical strategy. It is only when words are consolidated as orthographic units in memory that they are used to aid spelling (Orthographic$_2$).

Frith describes the development of each stage as contributing towards the multiple-route adult model of reading. For her, early logographic skills lead to the formation of initial lexical representations, alphabetic skills lead to the development of the sub-lexical system, and orthographic skill acquisition leads to the development of lexical reading.

Frith's model has received mixed support from subsequent research. She was right to assert that children first learn to read logographically, at least in English (Berninger, Abbott, & Shurtleff, 1990; Seymour & Evans, 1988), and they do use phonological decoding strategies in spelling before reading (Bradley & Bryant, 1983; Lie, 1991; Lundberg et al., 1988; Tornéus, 1984). However, there is little evidence to suggest that children first spell logographically, except for when they learn to spell their own name (Treiman, Kessler, & Bourassa, 2001). In addition, it would seem that children are able to use orthographic analogies in spelling at a far earlier stage of literacy development than Frith claims (Bosse, Valdois, & Tainturier, 2003; Goswami, 1986, 1993;).

Ehri (1986, 1991, 1994,1995)

Ehri has incorporated some ideas from the connectionist approach of Seidenberg and McClelland (1989) in her developmental theory of literacy acquisition.

According to her model, which has been revised over the years to accommodate new data, reading and spelling are almost one and the same thing; they share an underlying knowledge base which is derived from two sources: knowledge of the alphabetic system and word specific knowledge. The alphabetic system comprises knowledge of letter names, grapheme-phoneme correspondences, segmentation and blending of phonemes, awareness of larger units such as spelling patterns, and morphographs that symbolise syllabic units such as rime stems, root words, and affixes. Such knowledge does not require an explicit awareness of rules but operates implicitly. Word specific knowledge derives directly from reading and spelling experiences, and consists of information about the spellings of individual words. To a certain degree, word specific knowledge is supported by the alphabetic system, as spellings which lie outside this system are harder to remember. For instance, beginning readers can better remember nonsense spellings of words that share some sounds with the real word, so when *balloon* is spelled BLUN, it is better remembered than when it is spelled XGST (Ehri & Wilce, 1985).

In earlier formulations, spelling and reading were conceptualised as separate systems, each with three stages. In reading, these were logographic, phonetic cue, and cipher, and in spelling, they were called semi-phonetic, phonetic, and morphemic. In 1997, she combined the two and proposed four levels of reading and spelling development, which are broadly similar to those outlined by Frith (1985), although Ehri divides Frith's logographic phase into two sections, the pre-alphabetic and the partial alphabetic.

In the pre-alphabetic stage, reading is logographic and spelling is non-existent; children may use letters in their "writing" but these letters are allocated randomly and are usually combined with meaningless squiggles. The partial alphabetic stage occurs when children learn the names or sounds of alphabet letters. When faced with a new word, the child's knowledge of the alphabetic system is activated and it computes the connection between graphemes in the spelling and phonemes in the pronunciation. In the early stages, these connections are partial and children can only form connections between salient letters in words and their pronunciations. In addition, they tend to initially form connections between letters and letter names rather than letter sounds. In reading, this result in confusion between words that share salient letters, such as *beaver* and *brother*, and in spelling, children may write *beaver* as BR or BVR. Ehri cites two reasons for this partial representation of sounds: firstly, children have difficulty detecting and segmenting words into phonemes; secondly, they do not know how to represent all the sounds with letters, particularly vowel sounds. Consequently, children tend to read more words than they can spell, because reading can be achieved successfully with partial cues whereas spelling cannot.

By the Full Alphabetic Stage, children have developed the ability to detect more of the sounds that make up a word, so are able to segment words into spelling units (graphemes) that correspond to phonemes. In addition, they can attain good levels of reading accuracy for words conforming to letter-sound rules. However, their spellings in this stage show an over-literal use of the alphabetic principle; they stretch out sounds and consequently produce spellings like BALAOWS for *blouse*. When children gain more experience of print, and recognise that letter patterns reoccur across words, they enter the Consolidated Alphabetic Level. The recurrence of graphemes and phonemes in common patterns, such as 'oo' and 'n' making *-oon* in *moon, spoon, soon,* are consolidated into multi-letter units (e.g., *-oon; -ight*). With repetition, the spelling of a word becomes connected to its pronunciation and meaning and forms a lexical item. Figure 1.3 illustrates this development for reading.

Ehri argues that this connection process also applies to irregular spellings, because most letters in irregular words correspond to grapheme-phoneme rules. The letters that do not are flagged up in memory (e.g., I*LAND, S*ORD), or readers may create phonological mnemonics that emphasise silent letters (e.g., EYES-LAND for *island*).

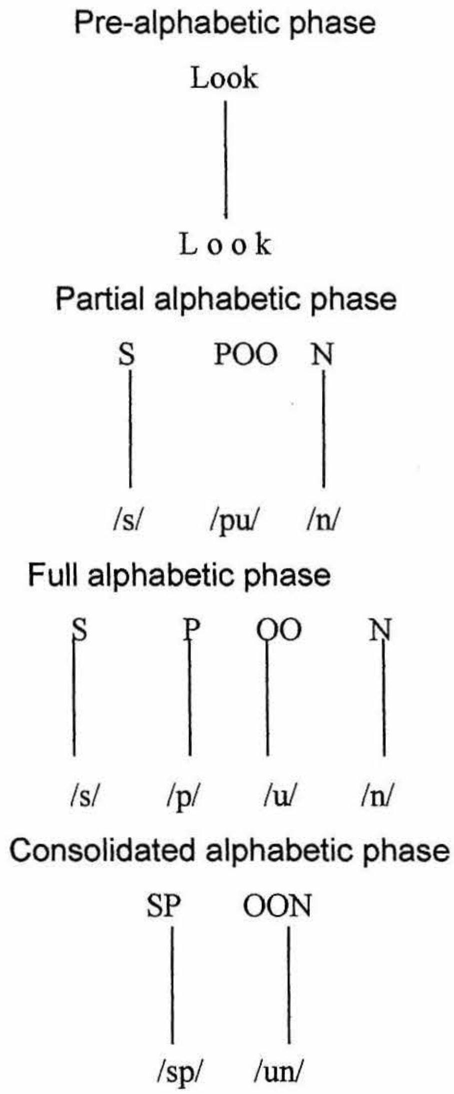

Figure 1.3. Illustration of how connections are formed in sight-reading during each of Ehri's phases of reading development. From Ehri (1997).

Although Ehri refers to her model as connectionist, details concerning the formation of connections are not well specified. By adopting a connectionist position, Ehri accounts for apparent stage-like behaviour as natural properties of the networks, so changes in reading and spelling strategies are the result of a change in the network's knowledge base rather than a developmental shift in underlying cognitive functioning. Consequently, children's failure to make analogies (i.e., to utilise shared orthographic features of words as an aid to reading and spelling), is actually due to the small numbers of connections between spelling patterns and pronunciation units rather than an inability to make analogies until later stages of cognitive development, as suggested by Piaget (1971). Therefore, if a corpus of sound-spelling patterns are established early on, children will be able to use these to make analogies in reading and spelling from an early age.

In Ehri's model, spelling and reading are symbiotic; reading has an effect on spelling because children retain word specific information through reading which they use in their spelling, and spelling has an effect on reading because it improves children's knowledge of the alphabetic system which helps them to decode new words.

A great deal of research supports Ehri's conclusions. Studies have found a transfer effect from reading to spelling (Ehri, 1980; Ehri & Wilce, 1987a; Foorman, Francis, Novy, and Liberman, 1991), and spelling to reading (Bradley & Bryant, 1985; Ehri & Wilce, 1987b; Lundberg et al., 1988; Uhry & Shepherd, 1993). In addition, by adopting a connectionist approach, Ehri's model can account for children's precocious use of analogies in reading and spelling, examples of which will be discussed in the following section.

1.5 The nature and role of phonology in literacy acquisition

Phonology refers to the sound units that occur in language. Words can be devised into sound segments at four levels (Treiman, 1992). The first level is the syllable (e.g., *sta-ble*), which divides naturally into a second level, that of the onset and rime, where the onset is the initial consonant/consonant cluster, and the rime consists of the vowel and remaining consonants (e.g., *b-ook, tr-ap*). The third level involves division of the rime into an onset (vowel) and coda (terminal consonants), such as *o-lt*. The final level is the division of initial consonants and final consonants into individual speech sounds, or phonemes (e.g., *t-r-i-p*); phonemes may correspond to letters, digraphs or trigraphs, such as "c", "ch", "tch". This hierarchy is represented in Figure 1.4. Tasks of phonological awareness can be separated into activities that demand the ability to identify and manipulate these sound units.

Rhyme awareness

Children as young as two show considerable ability to produce and detect rhyme and alliteration (Goswami & Bryant, 1990; Stackhouse & Wells, 1997), which suggests that rhyme awareness is an implicit skill. Pre-reading children who perform well on rhyme oddity tasks, such as detecting which is the odd one out among *pat, bat, ten* or *ball, bat, pen,* go on to become better readers and spellers (Bradley & Bryant, 1983).

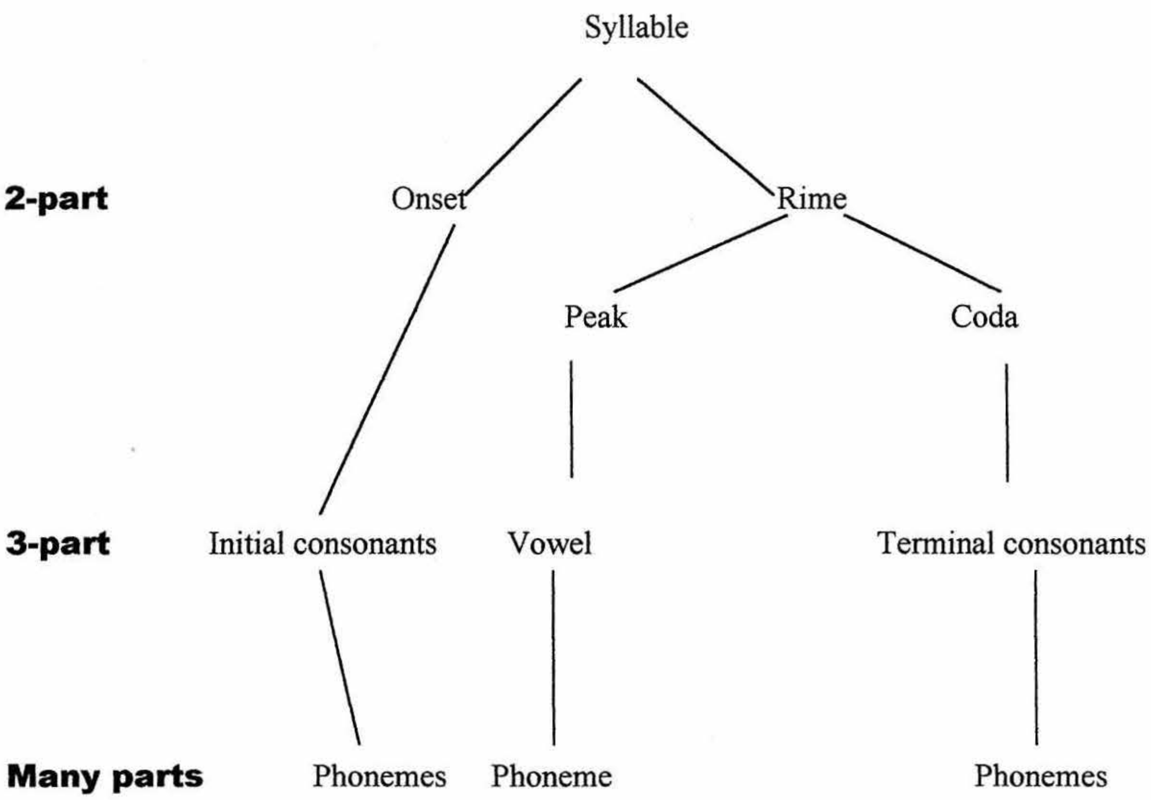

Figure 1.4. Hierarchical model of the structure of the syllable. From Seymour (1997).

Phoneme awareness

Phoneme awareness is a meta-phonological skill which pre-reading children find extremely difficult (Bruce, 1964); individuals are poor at explicitly identifying phonemes until they have learned to read and spell (Kirtley, Bryant, MacLean, & Bradley, 1989; Morais, Cary, Alegria & Bertelson, 1979). Even children with five years experience of reading and spelling have difficulty with complex phoneme detection tasks, such as "how many sounds are there in *pitch*?" (Ehri & Wilce, 1980). In fact, it appears that rhyming/alliteration and phoneme awareness each represent two independent sub-skills of phonological awareness (Goswami & Bryant, 1990; Muter, 1998).

Phonology and Reading

Theories of reading propose children first learn to read without recourse to the phonological properties of language. However, once children know the alphabet, which most of them do by the age of five (Worden & Boettcher, 1990), their initial logographic reading strategy is propped up by some awareness of sound. Ehri and Wilce (1985) showed that novice readers, who had some knowledge of the letter names of the alphabet, found it easier to learn phonetic nonsense spellings, like NE and MSK, than visually salient nonsense spellings, like FO and UHE, for the words *knee* and *mask*. Conversely, pre-readers, who had not yet mastered letter names, found it easier to learn the visually salient nonsense spellings.

In order to decode new words, children need some explicit awareness of phonology; their pre-existing implicit knowledge of phonology must be mapped onto the explicit skills by a process of bootstrapping from the moment they are exposed to print (Ehri, 1997).

A key issue in reading development centres on which type of phonological unit is most easily accessible to the child in the early stages: do they make analogies on the basis of shared phonemes or shared onsets and rimes? Goswami and Bryant (1990) point out that while it may seem easier for children to learn to read by dividing words into individual sound units, it is in fact a more difficult strategy for them to use. This makes sense for two reasons: firstly, when they start to read, children bring with them an awareness of rhyme and alliteration, whereas their awareness of phonemes comes as a consequence of reading. Secondly, in English, vowels are pronounced on the basis of subsequent consonants, so "o" in *hop* is a short vowel, whereas "o" in *hope* is a long vowel and corresponds to the letter name. It may be easier for a young child to see the orthographic similarity between rhyming words, like *hop, top, and mop,* and *hope, rope, cope,* and use these to decode a novel word like *flop* or *slope,* than to try to break these words up and sound out each letter – particularly in the latter case because the "o" read as /o/ would yield an incorrect pronunciation. Of course, there is a way to detect the different pronunciations, and that is by using the rule concerning the "magic e". However, children cannot possibly be given, or expected to remember, rules pertaining to all possible grapheme-phoneme combinations, yet they learn to read despite this. Consequently, learning letter sequences could be a more economical and less error-prone decoding strategy than phonemic segmentation.

Studies by Goswami (1986, 1988) have shown that reading words by analogy is easier for beginning readers than is reading by phonological recoding. Her basic strategy was to teach children, who could not read words on standardised reading tests, a clue word, like *beak*. The children were then shown several unfamiliar words and non-words, some of which were analogous to the clue (e.g., *bean, beal, peak, neak*), and non-analogous control words which shared three letters with the clue (e.g., *lake, pake*).

She found that children could read more analogous than non-analogous words, and among the analogous words, they were more successful at reading those that shared the rime (e.g., *-eak* as in *peak*) rather than the onset and vowel (e.g., *bea-* as in *bean*). However, after around six months of reading experience, children were increasingly able to make analogies based on onset and vowel. Goswami and Mead (1992) showed that children's use of onset-rime analogies correlated with their awareness of rhyme, whereas onset and part of the rime analogies was more strongly related to their awareness of phonemes. It should be stressed that the effects shown in Goswami's work were not due to phonological priming, because similar transfer did not occur when two words rhymed but differed in orthography (such as *head-said, most-toast*) (Goswami, 1993).

So what role do phonemes play in early reading acquisition in English? Morais, Mousty, and Kolinsky (1998) argue that phoneme awareness plays a pivotal role in reading development. Their assertion is based on two bodies of evidence: firstly, explicit teaching of phoneme awareness, coupled with segmentation skills training, leads to accelerated progress in reading (e.g., Hatcher, Hulme, & Ellis, 1994; Lundberg et al., 1988); secondly, they believe that explicit awareness of phonemes is necessary for irregular word reading. Their argument is based on findings that show how phonological decoding skills aid irregular word reading. Bryne, Freebody, and Gates (1992) found that second grade poor readers with good decoding skills were better at both regular and irregular word reading a year later than poor readers with poor decoding skills. Morais et al. (1998) posit that because explicit awareness of phonemic segmentation forms the basis for explicit awareness of higher order grapheme-phoneme rules, children who know these rules are in a better position to identify words which depart from these rules.

Seymour (1997) attempts to resolve the phoneme vs. onset-rime discussion. He argues, "a distinction is needed between implicit phonological development, which proceeds from larger units (words and syllables) through to intermediate units (onsets and rimes) to smaller units (phonemes), and a demanded sequence of literacy-related explicit awareness that develops in the opposite direction, from small units towards larger ones." (p. 327). Children's natural proclivity towards larger units may explain why onset-rime analogies are used early on, but are overridden by the demands of acquisition of the alphabetic principle. Support for this is provided by Seymour's work with Evans (1994b) which showed that children who had received two years of schooling were better able to segment words into small units (phonemes) than larger ones (onset-rime).

In view of the importance given to phonology by researchers of literacy development, one might be lead to believe that children read phonologically for quite some time. They don't. Once a word is known it is read by direct lexical access. Barron and Baron (1977) gave children aged between 6 and 13 years two tasks that involved matching pictures and written words. In the 'meaning' task they had to say which cards went together, so a picture of trousers would go with the word *shirt*. In the 'rhyming' task, they had to say which pairs rhymed, so the word *corn* would go with a picture of a horn. Children performed the tasks under two conditions: in silence and with concurrent vocalisation (i.e., saying "double" repeatedly), which is supposed to prevent the child from using a phonological reading strategy. The hypothesis was that if young children rely on phonological strategies in reading, they would be hampered on both of the tasks in the concurrent vocalisation condition, whereas the older children, whose lexical reading route was more developed, would only be hampered in the rhyming condition. In fact, the young children performed similarly to the older children; both groups made more errors on the rhyming task than on the meaning task in the concurrent vocalisation condition. This suggests that young children use a lexical reading route early on. Snowling and Frith (1981) have also provided evidence for beginning readers' ability to read lexically.

To conclude, phonological skills are a precursor of reading and play a role in written word acquisition. Whether the key unit of segmentation in initial reading is the onset-rime or the phoneme remains less clear. The onset-rime may be an easier unit from which to make analogies, but it depends very much upon the way teachers instruct children to 'attack' words. What is certain is that phoneme awareness is perhaps more important for spelling development, and its later appearance in a child's phonological awareness may partially explain why spelling is more difficult than reading.

Phonology and Spelling

Children's earliest spelling attempts are invariably error-laden, but their errors are quite systematic. Once they know letter names, they tend to over-rely on this knowledge in their spellings.

At first, they use one letter to represent a word. Usually, this is the initial consonant (Stage & Wagner, 1992), but sometimes they use the final one (e.g., R for the nonword /gɑ/ because the sound /ɑ/ is represented by the letter name 'r') (Treiman, 1994).

Although theorists suggest that beginning spellers will use letter names whenever it is possible to do so, this view is probably too simplistic. Treiman (1994) asked first grade children to spell a series of monosyllabic non-words ending in letters with a vowel-consonant sequence (i.e., *f, l, m, n, r, s*) like *var*, *kef*, *vel*, and *pem*. She reasoned that if they use letter names whenever it is possible to do so, they should produce consonant-consonant (CC) spellings like VR, KF, VL and PM. Although some children did follow this pattern, the incidence of CC spellings were far higher for non-words containing 'r' than any other consonant; 41% as opposed to 9% for *l* and between 2% and 4% for *m, n, f,* and *s*. Treiman suggested that /ɑr/ is probably more difficult to segment than /l/ or /m/. Indeed, a study of games involving the division of spoken syllables found that a vowel followed by the letter 'r' forms a specially tight bond (Derwing & Nearey, 1991). Treiman's study shows that the phonological properties of a letter's name affect the likelihood of children making particular types of spelling error; they are more likely to spell *car* as CR and *bell* as BL than they are to spell *mess* as MS and *ten* as TN.

Children continue to use letter names in concert with newly acquired knowledge of letter sounds, so typical spellings include LADE for *lady*, and GRAF for *giraffe*. They also tend to leave out consonants when they are part of a consonant cluster, particularly if they are the second or third consonant of the cluster. Examples include HASAK for *haystack*, and SET for *street*. Such errors may relate to children's extreme difficulty with locating consonants in consonant clusters in spoken language.

Once children's ability to locate more of the individual sounds in words improves, they rely on this alphabetic strategy virtually to the exclusion of other clues. For instance, they write TAYBEL for *table*, NOYS for *noise* and WEN for *when*. Interestingly, children are able to detect phonological correspondences which, although seemingly bizarre, actually make considerable sense, such as CHRAC for *truck* (because the /t/ in truck is affricated, so it sounds like /tʃ/).

So far, it can be deduced that children use phonemic segmentation, first partially then more completely, virtually from the outset in their spelling. There has been more debate concerning young children's use of analogy in spelling. Traditionally, it was suspected that children could not use analogies until late childhood. For example, Campbell (1985) used an auditory lexical priming paradigm to investigate how children spelled non-words like /prein/. If the children made analogies, they should spell it as PRANE if it is preceded by *crane*, and PRAIN if it is preceded by *brain*. Campbell found that only adults and children with a reading age of over 11 years made such analogies. But this study cannot be taken as conclusive evidence that children do not use analogies; it could be that the children in Campbell's study were unable to spell *crane* and *brain* in the first place, so obviously could not make analogies from these words.

Goswami (1988) tried to overcome this problem by presenting six-year-old children with a clue word (e.g., *beak*), telling them its pronunciation, and leaving the clue word in sight whilst they spelled orally presented words. The target word either shared a rime with the clue word (e.g., *beak-peak*), or a consonant-vowel unit (e.g., *beak-bean*) or three letters (e.g., *beak-lake*). Children made analogies from the first two types of words (i.e., *peak* and *bean*) but not the latter (e.g., *lake*). Goswami took this finding as support for the view that six-year-old children could not make analogies based on shared phoneme-grapheme correspondences.

Nation and Hulme (1998) point out two problems with Goswami's study: firstly, the clue word was visible throughout the task, so her results cannot be generalised to children's spontaneous writing. Secondly, although the words in the common letters condition shared three letters with the clue word, they did not share grapheme-phoneme correspondences. For instance, in *peak*, the phonemes are /p/, /i/, and /k/, whereas in *lake*, the phonemes are /l/, /œ/, and /k/, so although the same vowels are used in each word, they represent different phonemes.

Using five and six year old children, Nation and Hulme adapted Goswami's clue word paradigm and added a fourth 'common vowel' condition in which a phoneme was shared (e.g., /ɔ:/ as in *corn-port*). They replicated Goswami's finding that the non-word was spelled using the same pattern as the target word, and provided novel data showing that children could use common vowels as a unit for analogy equally as well as rime and consonant-vowel units. In a further experiment, they repeated the target word training but changed the testing conditions. Children were exposed to the 8 prime words, and the next day they were given a spelling test containing a mixed list of words and non-words (i.e., the 24 non-words, 3 from each of the 8 primes). They were given a response sheet and asked to tick when they heard a real word. When they heard a non-word they were asked to try to spell it. The results showed that, even when the prime word was not present, they were able to make analogies equally well for each of the three conditions (CV, rime, vowel).

Nation and Hulme (1998) also related the children's use of analogy to their phonological awareness and found that spelling by analogy relates more closely to phonemic-level rather than onset-rime level phonological awareness. The finding that young children can use analogies based at the phonemic level has also been shown by Bosse et al. (2003).

To conclude, it seems children rely heavily on phonological processing in spelling development. They are able to divide words into phonemes in order to spell them from a very early age, and can make analogies between sound units in words at a number of levels, from onset-rime to phoneme.

1.6 The nature and role of orthography in literacy acquisition

Orthography is the way in which a word is spelled, and awareness of a word's spelling pattern is referred to as orthographic knowledge. Many words in English cannot be spelled or read using direct grapheme-phoneme correspondences for a number of reasons. Their orthography might be determined by higher order phonological rules (e.g., *city* is pronounced /sɪti/ because 'c' before 'i' is /s/, and *code* is pronounced /kəʊd/ because 'c' before 'o' is /k/), grammatical rules (e.g., the /t/ sound in kissed is spelled *–ed* to denote its past tense status), or by their foreign language origin (e.g., *ballet, yacht*). Consequently, orthographic knowledge draws upon a number of capabilities: visual memory, grammatical knowledge, and awareness of foreign orthographies.

Models of reading and spelling suggest that awareness of orthographic rules comes later on in literacy development. However, studies show that very young children are able to detect orthographic principles; they can be aware that certain words are spelled a particular way, but may have no real explicit understanding of the phonological basis for these spellings.

One set of frequently referred to orthographic conventions concerns double letters. In English, the only vowels that can be doubled are 'o' and 'e'. When 'e' and 'o' are doubled, they create /i:/ and /u:/, (e.g., *reed, mood*), but when single they are /ɛ/ and /ɒ/ (e.g., *red, mod*). The doubling of consonants affects the pronunciation of the vowels that precede them. Single consonants tend to follow a long vowel (e.g., *later*), and double consonants follow a short vowel (e.g., *latter*). Double vowels and consonants rarely occur at the beginning of a word in English.

Cassar and Treiman (1997) examined the ability of children to match orally presented non-words with written representations (e.g., /seilɨp/ to *sallip* or *salip*), as well as their ability to say which of two visually presented non-words were more 'wordlike' (e.g., *nnus* vs. *nuss*; *gaad* vs. *geed*). Their participants ranged from kindergarteners to college students. They found even kindergarteners could identify vowels that could be correctly doubled, and double consonants that are more likely to occur in the middle or end of words rather than at the beginning. The ability to detect medial consonants as representing long and short vowels did not occur until the 6th grade, as predicted by models of reading and spelling. However, the ability of kindergarteners to see that *geed* and *nuss* were more wordlike than *gaad* and *nnus* illustrates how children are aware of orthographic conventions earlier than was traditionally thought.

1.7 The relationship between phonological and orthographic skills

There is no real agreement in the literature about the extent to which phonological and orthographic skills are related.

In adults, dual-route models suggest that lexical and sub-lexical routes function independently; whereas sub-lexical processes are underpinned by phonology, lexical processing is visual. Indeed, clinical case studies show that these routes can be dissociated in the developed brain (Funnell, 1983; Patterson, Marshall, & Coltheart, 1985). However, a series of studies on normal skilled adult readers have questioned this view by showing that phonology may play an important role in accessing orthographic representations (Lukatela & Turvey, 1994; Van Orden 1987, 1991; Van Orden, Pennington & Stone, 1992).

In the developmental literature, it has been argued that orthographic skills are parasitic upon phonological processing. Studies have shown that phonological skills facilitate the creation of orthographic representations (Dixon, Stuart, & Masterson, 2002; Ehri & Wilce, 1985; Rack, Hulme, Snowling, & Wightman, 1994; Share, 1995), and are predictive of later levels of orthographic knowledge (Muter & Snowling, 1997).

Phonological skills plausibly help with the formation of orthographic representations in three ways. Firstly, they reduce processing load because when faced with an irregular word, like *island*, a child can approximate most of the word's spelling by using phonic knowledge, so the segment that needs to be logographically encoded (i.e., the '*s*') is small (Ehri, 1997). Secondly, as Morais et al. (1998) suggest, children with good knowledge of phonological rules are more easily able to identify words that depart from these rules. Thirdly, early success in reading is determined by phonological skills (Bradley & Bryant, 1983). Therefore, good readers are more likely to engage in reading activities, which in turn increases their exposure to irregular words, so strengthening these words lexical representations (Share, 1995).

There have, however, been findings that contradict the view that orthographic skills are underpinned by phonology. There are indications that orthographic processing skills contribute significant variance in reading and spelling ability once variance associated with phonological processing has been partialled out (Barker, Torgeson & Wagner, 1992; Cunningham & Stanovich 1990, 1993; Stanovich & West, 1989).

In general, data favour the view that phonological skills and orthographic knowledge develop in interaction rather than independently (Ehri, 1997; Frith, 1985). Different processes underpin these skills; phonological skills are underpinned by phonological awareness, whereas visual memory and knowledge of higher order linguistic rules underpin orthographic skills. Both types of skill provide different contributions to reading and spelling; phonological skills are crucial during the acquisition of literacy and in tackling novel words, whereas orthographic skills are vital for irregular word reading and spelling.

CHAPTER 2

DEVELOPMENTAL DYSLEXIA

2.1. What is dyslexia?

Many children are poor readers, but their underachievement can usually be attributed to below average ability, emotional-behavioural disorders (e.g., ADHD) or environmental factors, such as school absence or socio-cultural deprivation. Conversely, the reading and writing attainments of dyslexic children are significantly below the level predicted on the basis of their intelligence, despite normal functioning and adequate educational opportunity (Thomson, 1990). The severity and nature of the disorder varies from one individual to the next. It is perhaps best conceptualised as a syndrome, though this view is not without critics (see Stanovich, 1991), because, in addition to their reading and spelling problems, studies have reported that dyslexics typically display some of the characteristics shown below:

- Directional confusion
- Messy handwriting and bizarre spelling
- Finger differentiation problems
- Visual perceptual difficulties
- Left handedness
- Cerebral dominance abnormalities (i.e. lack of a dominant side)
- Short-term memory deficits

- Difficulty with remembering sequences
- Motor dysfunctions (poor balance and co-ordination, clumsiness)
- Difficulty with mental arithmetic

Although not categorised as a learning difficulty in Britain until the 1981 Education Act, developmental dyslexia is by no means a new disorder. The first cases of 'congenital word blindness', as opposed to the acquired variety, whereby skilled readers lose some facet of their reading ability after brain damage, were reported separately by both Kerr and Pringle-Morton in 1886 (cited in Pumfrey & Reason, 1991). The time lapse between discovery and official recognition was largely due to hostile debate in educational circles about whether it was a real disorder or merely a useful label that exonerated children who did badly at school, or excused poor teaching.

2.2 Incidence

Dyslexia has been reported in most countries with universal education, and is found in both European and non-European languages (Ramaa, Miles, & Lalithamma, 1993). The condition often runs in families and dyslexics come from the full spectrum of ability ranges and socio-economic groups (e.g., Badian, 1994). Although exact figures are difficult to obtain due to variations in the diagnostic criteria used, it is estimated that between 4-10% of school-age children are dyslexic (Stein, 2001; Thomson, 1982; Yule, Rutter, Berger & Thompson, 1973) with a male-to-female ratio of 4:1.

2.3 Identification of dyslexia

A contentious area within education and research concerns how one distinguishes dyslexic children from others who are not very good at reading. Given that there are limited resources to help children with learning difficulties, educationalists have had to find a way of delineating children whose reading and spelling problems are due to disability from the general population of poor readers. This is so that dyslexic children can be provided with the specialist support they need, rather than the more general help required by 'garden variety' poor readers (Ellis & Large, 1987).

Currently in the UK, the diagnostic procedure is based on evidence which suggests that IQ and literacy skills are highly correlated (e.g., Clark, 1970; Rutter & Yule, 1975). Children are referred to an educational psychologist if additional support within the classroom setting has failed, and if their teachers feel the child's abilities in literacy are at odds with their general intellectual skills. If an educational psychologist detects a 'significant' discrepancy between the child's IQ and their reading and spelling attainments, in addition to two or more of the characteristics described in the previous section, particularly phonological impairments, they are classified as 'dyslexic' (Pumfrey & Reason, 1991).

This process cannot adequately detect dyslexia in children whose general intellectual levels are very high or low. For instance, extremely bright dyslexic children may read and spell at a level commensurate with their chronological age, when they should be reading at a higher level. Because they are not behind their peers, their dyslexia may go unnoticed by teachers. Similarly, children with general learning impairments can be dyslexic, but their weaknesses in literacy might be attributed to their below average ability.

A keen objector to the use of IQ in the diagnosis of dyslexia has been Stanovich (1991; Stanovich, Siegel, & Gottardo, 1997), who argues that the delineation of poor readers from dyslexics on the basis of IQ is morally and theoretically erroneous. He points out dyslexic children have not been shown to perform differently from poor readers on any task that taps into the information processing systems which subserve reading.

2.4 One disorder or many? Subtypes of developmental dyslexia

The idea that sub-types of developmental dyslexia might exist was stimulated by reports from cognitive neuropsychologists about the dissociation of particular aspects of reading skills in acquired dyslexia (Funnell, 1983; Marshall & Newcombe, 1980). An overview of these can be found in Ellis (1993), but the three subtypes with relevance to developmental dyslexia are:

Phonological Dyslexia. In phonological dyslexia, the lexical reading is retained but the phonological route is impaired, so non-word reading is impoverished.

Surface Dyslexia. In surface dyslexia, the phonological reading route is retained but the lexical reading route is impaired, so irregular words are read more poorly than regular words. Irregular words are dealt with by sub-lexical processes, and this leads to the production of regularisation errors, such as reading *pint* as if it rhymes with *hint, mint, stint,* etc.

Deep Dyslexia. In deep dyslexia, concrete words are read more accurately than abstract words, non-word reading is impoverished, and visual errors are common (i.e., *sympathy* for *symphony*). The most striking feature of their reading concerns their semantic errors; they read *forest* as *trees* and *dog* as *cat*. Some errors are visual to semantic, so *price* may be read as *crown* via the route *price*→*prince*→ *crown*.

In the developmental literature, cases of phonological dyslexia have included those of H.M. (Temple and Marshall, 1983), and J.M. (Hulme & Snowling, 1992; Snowling, Stackhouse, & Rack, 1986; Snowling & Hulme, 1989; Snowling, Hulme, Wells, & Goulandris, 1992). They also include studies of adults with developmental dyslexia whose non-word reading was greatly impaired compared to their relatively good real word reading; in these cases, the adults in question had attained adequate levels of literacy through the rote memorisation of letter strings (Campbell & Butterworth, 1985; Funnell & Davidson, 1989). As phonological deficits are found in many children with developmental dyslexia, the case studies above differ from the majority quantitatively rather than qualtitatively.

More controversial has been the supposed existence of developmental surface dyslexia. Coltheart, Masterson, Byng, Prior, and Riddoch (1983) reported the case of C.D., a 15 year-old girl with a reading age of 10 who over-employed the sub-lexical route in reading; her ability to read irregular words was impaired, so she read words like *quay* as /kwei/. However, her sublexical reading route was also quite impaired, so C.D. does not present as a clear-cut surface dyslexic. However, in the case of Allan (Hanley, Hastie, & Kay, 1991), a 22 year-old mechanic, there was a clearer dissociation; he demonstrated normal non-word reading in conjunction with poor irregular word reading. A further case is that of J.A.S., a 22 year-old undergraduate, who was more impoverished in irregular word reading and spelling than on non-word reading and spelling (Goulandris & Snowling, 1991).

Studies of developmental surface dyslexia have been criticised for failing to provide adequate control groups. Bryant and Impey (1986) suggested that comparison data may show that surface dyslexic patterns are the result of impoverished reading experience rather than specific impairment to the development of a lexical reading route. Castles and Coltheart (1993) acknowledged these criticisms and conducted a large study comparing 53 dyslexics with 56 chronological age matched controls. The children were assessed on non-word reading and irregular word reading. Regression analyses was used to differentiate between phonological and surface patterns by assessing the relative imbalance between the two types of reading: non-word > irregular words = surface dyslexia, and irregular words > non-words = phonological dyslexia. They found 45/53 of their dyslexic sample could be thus categorised: 16 children were surface dyslexics and 29 were phonological dyslexics.

When Castles and Coltheart's (1993) data were reanalysed using reading level matches by Stanovich et al. (1997a, 1997b), it was found that most of the surface dyslexics had profiles similar to that of younger normally developing children. Consequently, they suggested that surface dyslexia-type patterns of reading are most probably the result of a developmental delay rather than lexical route deficiencies. They concluded that surface dyslexia may stem from a mild impairment to phonological decoding which, combined with poor reading experience, results in limited development of lexical representations. This notion is supported Snowling, Bryant, and Hulme (1996) and Manis, Seidenberg, Doi, McBride-Chang and Peterson (1996).

Developmental deep dyslexia appears to be extremely rare, and although cases of children who make semantic errors have been reported (e.g., C.R. by Johnston, 1983) the proportion of these errors are not high in relation to visual errors. Probably the best-documented case to date is that of K.J. (Stuart & Howard, 1995). K.J. showed poor non-word reading, which suggested arrest during the stage in which grapheme-phoneme connections are formed, and also made many semantic errors in reading. Fascinating as such cases are, their rarity means that their theoretical implications far outweigh their pragmatic importance; deep dyslexia is not a serious candidate as a subtype of developmental dyslexia.

2.5 Do dyslexic children read and spell differently from normal readers and spellers?

A starting point for researchers attempting to locate the cause of dyslexia is to address the question of whether dyslexics make qualitatively different errors in reading and spelling compared to younger children whose literacy development is normal.

Before discussing the data, it is important to consider the experimental designs used in studies:

Chronological age matches (CA): This would involve comparing dyslexic children with peers of the same age and underlying abilities (i.e., non-verbal IQ). Studies employing CA matches generally show that dyslexics perform more poorly on a range of tasks that tap into cognitive processes such as language and memory. However, these results are open to dual interpretation: either the dyslexics are poor readers because they perform poorly on a specific cognitive task, or they perform poorly on a task because they are poor readers. Data from CA studies cannot confirm whether the reading problems of dyslexics are due to a deficit or a developmental delay.

Reading age matches (RA): This involves comparing dyslexics with younger, normally developing children whose reading ages (and/or spelling ages) match those of the dyslexic child. Any differences in cognitive performance could not be due to reading skills, as both groups are at the same level on this factor. If dyslexics perform more poorly than RA controls on a certain cognitive task, this would strongly indicate that they had some kind of deficit in this domain. Although preferable to chronological age matched studies, there are weaknesses with the RA design. Because the dyslexics are older, they may well have developed compensatory strategies to circumvent their difficulties, and will have been taught things in school that younger children would not know. Deficits in a domain such as verbal memory, for instance, might not be apparent (even though they exist) because the older dyslexic child is better able to draw on their kinaesthetic or visual memories to encode information. One way around this is to look at qualitative and quantitative differences in the performances between groups (see Rack, 1985). In addition, if 10 year-old dyslexics are compared to young RA controls (i.e., aged 6 or 7), tasks may need to be adapted to suit the younger children in order to maintain their interest level.

Garden variety poor reader matches (GVPR): As mentioned earlier, the main way in which dyslexic children are isolated as a 'special' group from other children with reading difficulties is through the use of IQ tests. Generally, dyslexic children have superior intellectual skills in comparison to 'garden variety' poor readers. Given the homogeneous performances of PR and DR groups on a number of literacy related and cognitive tasks, it is not surprising that many researchers do not distinguish between these groups in their research, hence the proliferation of studies that use the generic label 'poor readers' or 'reading disabled'. However, the use of PR controls is useful when assessing the relative influences of intelligence on reading performance.

Real word reading

Ehri and Saltmarsh (1995) have reported qualitative differences in reading between dyslexic children and reading age controls. They replicated a Dutch study by Reitsma

(1983) which suggested that dyslexics differ from normal readers in their ability to remember letter details. Good and poor reading 1st graders (aged around 6) were compared to and 8-year-old dyslexic children. The dyslexic children's reading ability was intermediary between the good and poor 1st grade readers. They gave the children 16 words, all of which were simplified phonetic spellings of real words, like *messenger* spelled MESNJR. Three days later they read the words again, but this time original spellings were mixed in with altered versions of the targets. The targets were altered at initial, medial and final letter position, for example: *jenral* → *genral* (general); *latr* → *latrn* (lattern); and *rlax* → *rlaz* (relax).

Both groups of 1st graders were slower at reading the altered words in each of the three conditions, and the good readers were more affected than the poor readers. The dyslexic children, however, who were better readers than the low reading 1st graders, were only slowed down by alterations at the start and end of words, not those in the middle. These results show that dyslexic readers are less sensitive to medial letters, and have less complete representations for sight words in memory than normal readers, even when the normal readers are poorer on standardised tests. This result could either be interpreted as suggesting that dyslexics are impoverished in their ability to make complete grapheme-phoneme correspondences, or that they have a visual attentional problem which affects their ability to process the middle letters of words.

Real word spelling

There is no evidence to suggest that dyslexics are more likely than younger normal spellers to make reversal errors (e.g., *day* → *bay*) or sequencing errors (e.g., *you* → *yuo*) (Nelson, 1980).

In order to assess whether dyslexic children have more problems learning alphabetic principles, the question of whether they make more nonphonetic errors in spelling has been assessed. Nonphonetic errors have been operationally defined as those in which a phoneme is not represented, such as DOO for *door*, PAD for *plaid*, and WET for *went*. Four studies have found no difference between dyslexic children and spelling age matched younger children (Bradley & Bryant, 1979; Moats, 1983; Nelson, 1980; Pennington et al., 1986). On the other hand, studies by Bruck (1988) and Olson (1985) found dyslexic children made more nonphonetic errors. However, Treiman (1997) has questioned their results, because the dyslexic children made more of all kinds of errors on real words. Even though the groups were matched on standardised tests of spelling, Treiman argued that these scores may not have demonstrated their true ability.

Stronger evidence for the notion that dyslexic children's spelling is less phonetically accurate than normal children's comes from a study by Bruck and Treiman (1990). They compared 23 ten year-old dyslexic children with normal 7 and 8-year-olds on their spelling of words with many consonant clusters. The dyslexics made 36% non-phonetic errors compared to the younger children's 21%. Similarly, Kibel and Miles (1994) found older dyslexic children, aged between 9 and 15, made more non-phonetic errors than younger normal spellers. Both studies reported that the dyslexics made more errors omitting consonants from consonant clusters, so produced spellings like BOT for *blot*.

In a review of the literature, Treiman (1997) argues that it is important to be cautious when interpreting the results of studies assessing the phonological accuracy of dyslexic children's spelling. She argues that many errors that would be classified as nonphonetic by researchers, such as WOM for *warm* and JRY for dry, are common among normally developing children. In addition, she suggests that such errors are, in fact, phonologically based, so the incidence of such errors among dyslexic children are not necessarily suggestive of their failure to apply phonological rules in spelling.

The question of whether dyslexic children are less aware of orthographic conventions in spelling has been addressed by a number of researchers. In general, it has been found that dyslexic children's spelling errors are just as orthographically plausible as those of younger normal spellers (e.g., spelling cake as CACK, not CKAK) (Nelson, 1980; Olsen, 1985). If anything, there is a suggestion that because dyslexic children have a tendency to circumvent their phonological problems by relying on visual cues (Rack, 1985), they are better than younger children on orthographic tasks. For instance, Siegel, Share, and Geva (1995) compared dyslexic children from the 1st to the 8th grade with reading age matched controls and found the dyslexics were better at judging the wordlikeness of non-words (e.g., *moke* vs. *moje*).

Non-word reading

A fairly robust finding has been that dyslexics are m`ore impoverished than reading age matched controls in their ability to read non-words like *tegwop* and *molsmit* (e.g., Felton & Wood, 1992; see Rack, Snowling, & Olson, 1992 for a review). Pring and Snowling (1986) suggested that dyslexic children attempt to circumvent their difficulties with phonology by relying more heavily on semantic cues when reading non-words. They found dyslexic children read a non-word, like *nirse,* faster if it was preceded by *doctor* than by an unrelated or neutral word; in normal readers, this context effect was less pronounced. The non-word reading deficit in dyslexia holds for a number of languages (e.g., Wimmer, 1996).

Non-word spelling

In comparison to the large number of studies on non-word reading in dyslexia, there are few studies of non-word spelling, and the results are difficult to interpret due to methodological weaknesses. Siegel and Ryan (1988) found dyslexic children made more non-word spelling errors compared to reading age matches, but they did not test the children on real word spelling, so it could have been that the controls were better spellers anyway. A study by Martlew (1992), which reported a significant result, in that dyslexics made more errors than spelling age matched children, can be criticised for its small sample size (12 dyslexics) and low number of stimuli (only 3 non-words were used). Conversely, Bruck (1988) found no differences in non-word spelling between dyslexics and spelling age matched controls.

2.3 Theories of developmental dyslexia

The principal current theories of are described below.

The phonological theory

The important finding that children's ability to detect and produce rhyme predicts their later literacy development, and that training in phonological skills improves literacy acquisition

(Bradley & Bryant, 1983; Lundberg et al., 1988), motivated a great deal of research examining the phonological awareness of dyslexic children.

The phonological theory postulates that dyslexic children have specific problems with the representation, storage and/or retrieval of speech sounds. This can account for why dyslexic children have such problems learning to segment words into phonemes in reading and assemble spellings. Many studies have shown that, in comparison to children of similar reading ages, dyslexic children perform more poorly on tasks involving phonological processing, such as phoneme deletion and non-word repetition (e.g., Fawcett & Nicolson, 1995a; Snowling, 1995; Stanovich & Siegel, 1994).

Even when dyslexics do not perform more poorly than reading age matches on phonological tasks, they process verbal information in a qualtitatively different way. For example, Rack (1985) found they were more likely to remember word pairs that were orthographically similar, regardless of phonological similarity (e.g., *how-low*, *farm-harm*), whereas normal readers tend to remember word pairs that sound alike, despite orthographic differences (e.g., *nose-goes*, *how-now*).

The plausibility of the phonological deficit hypothesis is strengthened by the fact that phonological processes are involved in a range of the peripheral, though not insignificant, difficulties exhibited by dyslexic children. It has been argued that phonological deficits can account for short-term memory deficits found in dyslexic children (Nelson & Warrington, 1980), as well as their deficits in mathematics (Miles, 1983), rapid automatic naming (Denckla & Rudel, 1976a, 1976b), object naming (e.g., Snowling, Van Wagtendonk & Stafford, 1988), and the repetition of multisyllabic nonsense words (e.g., Brady, Poggle & Rapala, 1989). Until recently, phonological deficiencies were also believed to account for poor speed of processing deficits among dyslexic children. However, it appears this constitutes an independent deficit (Wolf & Bowers, 1999).

The phonological deficit account of dyslexia (e.g., Frith, 1985, 1997; Liberman & Shankweiler, 1985; Snowling, 1981, 1987, 2001) has been the dominant theory of dyslexia for a number of years. Theorists who favour this view suggest the role of phonology in dyslexia is causal, and originates from congenital dysfunction of the left-hemisphere perisylvian brain areas. Both post-mortem anatomical studies (e.g., Galaburda, Sherman, Rosen, Aboitiz, & Geschwind, 1985; Geschwind & Galaburda, 1985) and functional brain imaging studies have shown dysfunction in this region of the brain among dyslexic individuals (Brunswick, McCrory, Price, Frith & Frith, 1999; McCrory, Frith, Brunswick, & Price, 2000; Paulesu et al., 1996; Pugh et al., 2000; Shaywitz et al., 1998; Shaywitz et al., 2002; Temple et al., 2001).

Within the phonological account, ideas diverge as to the loci of the phonological impairment. Some theorists claim that while the phonological lexicons involved in speech perception and comprehension are functioning normally, the processing of phonology in relation to language manipulation is impaired, which places the deficit at a metaphonological level. The problem with this view is that dyslexics also have difficulties with implicit phonological tasks, such as rhyme detection, and have phonologically related deficits, like poor short-term memory, which extend beyond reading and writing.

A more popular view is that phonological impairments are underpinned by defective speech processing systems. Phonological impairments cause poorly specified, or "fuzzy" word representations (Brady, 1997; Stackhouse and Wells, 1997). Most dyslexic children do not have problems discriminating between gross sound differences in words, and speech discrimination abilities are not predictive of reading achievement (Mann & Ditunno, 1990).

However, there is evidence that dyslexic children do have speech perception difficulties on subtler measures, such as categorical perception tasks. In a categorical perception task, the child listens to a speech continuum in which there are gradual changes between two phonemes, like /ba/ and /pa/. Pairs of items are presented, usually at a fixed distance on the continuum, and listeners are asked to judge if they are the same or different. It appears dyslexics have particular difficulty when the stimuli are phonetically similar (Godfrey, Syrdal-Lasky, Millay, & Knox, 1981; Werker & Tees, 1987).

These subtle speech-processing difficulties are apparent before children learn to speak. A Finnish study found that 6 month old babies at risk of dyslexia (i.e., with one or more dyslexic parents) (DeFries, Stevenson, Gillis, & Wadsworth, 1991; Lubs et al., 1993) were less able to discriminate between the duration of a segment in a nonsense word (i.e., ata vs. atta) (Lyytinen, 1997). Converging evidence is provided by Locke, Hodgson, Macaruso, Roberts, Lambrecht-Smith, and Guttentag (1997), who found 'at risk' children aged between 2 and 5 years of age generally performed more poorly than controls on expressive language, picture naming, phonological processing and short-term memory, though they found no differences for syntactic processing.

The rapid auditory processing theory

This view postulates that phonological deficits are the result of a more basic, non-linguistic auditory deficit. Tallal and her colleagues (Tallal, 1980, 1984; Tallal, Miller & Fitch, 1993) have found children with written and spoken language learning difficulties are poor at perceiving short or rapidly changing sounds. The basic paradigm used in these studies has been to ask children to make temporal order judgements of speech stimuli. Children are presented with two stimuli, such as /dɑ/-/gɑ/ and have to judge their identity and order. The length of the interval between stimuli and the duration of the stimuli are manipulated. The basic finding has been that dyslexic and language impaired children perform less well than controls on temporal order judgements for brief, rapidly presented tones (75ms in duration). This auditory temporal processing deficit is general, so affects the ability to judge a range of stimuli, like tonal changes and frequency discrimination (Ahissar, Protopapas, Reid & Merzenich, 2000; McAnally & Stein, 1996) (see reviews by Farmer & Klein, 1995; McArthur & Bishop, 2001).

Auditory processing deficits can be accounted for at a biological level by the magnocellular theory (see below).

The visual theory

Current proponents of a visual theory do not debate the phonological deficit approach, but rather suggest that some dyslexic individuals have additional difficulties with visual processing (Livingstone, Rosen, Drislane & Galaburda, 1991; Lovegrove, Bowling, Badcock & Blackwood, 1980; Stein & Walsh, 1997). Although early theorists suggested visual deficits were perceptual (i.e., impaired interpretation of visual stimuli by the visual cortex) (e.g., Stanley, 1975), it appears this is not the case, because dyslexics do not have visual perceptual difficulties when stimuli are non-symbolic (e.g., Ellis, 1981; Swanson, 1984).

The notion that some dyslexic children have deficits in peripheral visual processes (i.e., the physical processes involved in vision) has received mixed support. Such deficits may take the form of faulty eye movements (Pavlidis, 1981; Rayner, 1978a), though this finding is not unanimous (e.g., Black, Collins, Deroach, & Subrick, 1984; Olson, Kliegl, and Davidson, 1983), and poor binocular convergence (Cornelissen, Munro, Fowler, &

Stein, 1993; Stein & Fowler, 1993; Stein, Richardson, & Fowler, 2000b) (though see Goulandris, McIntyre, & Snowling, 1998, for a null result).

Proponents of the visual theory suggest the aetiology of visual dysfunction in some dyslexic individuals is a weak integration between the two pathways that extend from the retina to the visual cortex. The transient (magnocelluar) pathway deals more effectively with bold, holistic visual stimuli but has low acuity, whereas the sustained (parvocelluar) system processes detailed information. The two systems work in parallel, though there is some communication between them, and the systems exert inhibitory effects on each other. It has been suggested that in dyslexic children, these systems work out of synch.

Hogben (1997) outlines two theories, which he calls A and B, about how visual transient deficits may be involved in reading difficulties. Theory A suggests that the dyslexic's transient system is weak and fails to inhibit the sustained system. The corollary of this would be that each fixation on a word in text would be carried forward to the next fixation, leading to scrambled representations of letter strings. In Theory B, the transient system is too slow, so is unable to provide direction to the sustained system, which accounts for unstable eye fixations.

Behavioural studies show that, in comparison to controls, dyslexic children have deficits in their transient system; they are poorer at detecting contrast or fast moving stimuli or detecting high frequency flickers (Martin & Lovegrove, 1987). Psychophysical studies have shown dyslexics have decreased sensitivity in the magnocelluar range (Cornelissen, Richardon, Mason, Fowler, & Stein, 1995; Lovegrove et al., 1980), and biological support comes from anatomical studies (Livingstone et al., 1991; Galaburda and Livingstone, 1993) and brain imaging studies (Eden et al., 1996), which report abnormalities in the magnocellular layers of the lateral geniculate nucleus.

Automaticity deficits/Cerebellar Deficit Hypothesis

This theory postulates that many of the cognitive impairments observed in dyslexic children are due to a general difficulty with both motor control and the acquisition of automatic skills (Nicolson and Fawcett, 1990).

The impetus for this theory comes from two well-established findings in the dyslexia literature. The first is that dyslexics have poor short-term memory and are slower at processing tasks involving verbal information (Miles, 1983). As memory span is related to speed of articulation (Ellis & Hennelly, 1980), and speed of articulation is affected by motor control processes, the memory deficits in dyslexia could be accounted for by motor control deficits. A second is that young dyslexic children often have problems with learning automatic skills that, once mastered, require minimal levels of conscious awareness, such as swimming, riding a bike, driving, typing, and making grapheme-phoneme correspondences (Miles, 1983).

Nicolson and Fawcett (1990) postulated that older dyslexic individuals appear to cope with motor tasks that require automaticity because they allocate more conscious attention to such tasks. Consequently, dyslexic children should perform more poorly in automatic motor co-ordination tasks (they selected balance) in situations when other demands are made on conscious attentional processes (i.e., dual task conditions). Dyslexic and non-dyslexic children were asked to stand on a beam on one leg, two legs, and then walk on the beam in silence (single task) or whilst counting backwards (dual task). The dyslexics performed similarly to the other children in the single task condition, but were far unstable when the counting task was added. This finding has been replicated for a range of motor tasks (Fawcett & Nicolson, 1992, 1995b, 1999; Fawcett, Nicolson & Dean, 1996;

Nicolson & Fawcett, 1994), and time estimation, which is a non-motor cerebellar task (Nicolson, Fawcett, & Dean, 1995).

Proponents of this theory claim that the biological basis for automaticity and motor control deficits lies in dysfunction of the dyslexic's cerebellum because, among other things, the cerebellum is involved in controlling speed of articulation and the acquisition of automaticity. This claim is supported by brain imaging studies that show abnormalities in the cerebellum of dyslexics (Nicolson et al., 1999; Rae et al., 1998).

The Magnocellular Theory

The magnocellular theory aims to integrate the main explanations of dyslexia, and thus account for the full range of behavioural difficulties experienced by dyslexic individuals. It is an extension of the magnocellular theory of visual deficits; proponents argue that magnocellular imbalances are widespread in dyslexics, and occur in a number of brain pathways (auditory, visual and tactile).

In addition to the evidence relating to vision (see Visual Theory), studies show that dyslexics are poorer at detecting auditory frequency changes in real time (Stein and McAnally, 1996; Witton et al., 1998). Tracking frequencies in real time appears to be a function of large cells in the auditory system which may be similar to the magnocellular neurones in the visual system (Trussell, 1998). Therefore, magnocellular dysfunction in auditory pathways can accommodate both the rapid auditory processing and phonological theories of dyslexia (see Stein, 2001, for a review).

The magnocellular theory can plausibly account for some of the peripheral manifestiations of dyslexia which are unrelated to literacy or language. Skin sensitivity to touch is controlled by magnocellular performance in the dorsal column division of the somaesthetic system, and studies show dyslexics have poorer touch sensitivity than control groups (Grant, Zangaladze, Thiagarajah, & Saathian, 1999; Stoodley, Talcott, Carter, Witton, & Stein, 2000). Poor automaticity skills can also be explained by magnocellular dysfunction, because the cerebellum is the recipient of heavy input from magnocellular pathways.

Biological data support the existence of magnocellular imbalances in visual and auditory centres. Post mortem examination of dyslexics' brains have shown that large neurones of the left medial geniculate nucleus are smaller than those on the right side or in control brains (Galaburda, Menard, & Rosen, 1994).

Evaluation of theories

There are weaknesses in all of the theories outlined above.

The main problem with the phonological theory is that it cannot account for a range of the additional difficulties reported in dyslexic populations, such sensory difficulties and motor control problems. Some key impairments reported in dyslexics which were traditionally explained within a phonological framework have now been accounted for more successfully by other approaches. For instance, difficulties with rapid automised naming (Denckla & Rudel, 1976a, 1976b) now appear to constitute a separate deficit (see Wolf & O'Brien, 2001, for a review). Advocates of the phonological theory would counter such criticisms by arguing that peripheral problems, though present in some dyslexics, are not the cause of reading failure (Snowling, 2001).

Two criticisms of the cerebellar theory have been highlighted by Ramus, et al. (2003a). Firstly, they argue that Fawcett & Nicolson's posited link between articulation and phonology is based on a now redundant motor theory of speech that suggests phonological representations are based on speech articulation. In fact, those with apraxia of speech and dysarthria can develop normal phonological representations (Ramus, Pidgeon, & Frith, 2003). A further problem is that motor problems have not been found in some studies of dyslexic populations (e.g., Kronbichler, Hutzler, & Wimmer, 2002; Van Daal & Van der Leij, 1999; Wimmer, Mayringer, & Landerl, 1998). Where motor problems are detected, they are typically found only in a subgroup of dyslexics (Ramus et al., 2003a; Yap & Van der Leij, 1994).

The magnocellular theory is based on the assumption that (a) visual and auditory deficits exist in dyslexics, and (b) when they do, they are underpinned by magnocellular dysfunction. This theory has come under criticism because: (a) visual and auditory deficits have not been found in some studies of dyslexic populations (Visual: Johannes, Kussmaul, Munte, & Mangun, 1996; Victor, Conte, Burton, & Nass, 1993. Auditory: Heath, Hogben, & Clark, 1999; McArthur and Hogben, 2001) and when they are found the incidence rate varies considerably from one study to the next (Visual: Cornelissen, Richardson, Mason, Fowler, & Stein, 1995; Witton et al., 1998. Auditory: Mody, Studdert-Kennedy, & Brady, 1997; Rosen and Manganari, 2001; Tallal, 1980); and (b) visual deficits that are reported in dyslexics are not always based in the magnocellular system (Amitay, Ben-Yehudah, Banai, & Ahissar, 2001; Skottun, 2000), and the same applies to auditory deficits (e.g., Share, Jorm, McLean, & Matthews, 2002).

Making sense of the conflicting evidence concerning the presence or absence of impairments in phonology, motor control, and magnocellular function among dyslexic individuals is only problematic if one seeks to find a single cause for dyslexia. It may well be the case that the different findings from different studies are due to the simple fact that dyslexia is underpinned by different processes in different individuals.

A recent study by Ramus et al. (2003a) shows how dyslexic individuals do not present a homogeneous group in terms of their cognitive functioning. They assessed the plausibility of three theories of dyslexia (phonological, magnocellular, and cerebellar) by using a multiple case study design on 16 dyslexic undergraduates and 16 same aged controls. After assessing the groups on a full battery of tests, they identified those who were impaired in each domain (i.e., visual, auditory, motor, phonological). They found all 16 had a phonological impairment, 10 had an auditory impairment, 4 had a motor impairment and 2 had a visual impairment. They concluded that their data supported the phonological theory, but they acknowledged that additional impairments at the sensory and motor level were present in certain individuals. However, their results could have been due to a selection bias, because their dyslexic students were all volunteers who had received a formal diagnosis of dyslexia by an Educational Psychologist in secondary school or earlier. As mentioned in section 2.3, Educational Psychologists use a discrepancy model as the basis for their diagnosis, but they also give heavy credence to the presence of phonological impairments before making a decision about whether or not a child is dyslexic. Consequently, children whose reading and spelling difficulties might be underpinned by visual processing problems or motor difficulties might be under-represented in the clinically diagnosed dyslexic population.

To conclude, dyslexia is a condition affecting a small but significant number of children. It is most probably biological in origin, and the tendency to become dyslexic appears to be genetic. The core deficit is phonological; weaknesses in this aspect of language processing disable dyslexics from reading and spelling because they hamper the processes involved in segmentation and blending. However, phonological deficits may not be sufficient to account for the difficulties experienced by all dyslexic individuals.

CHAPTER 3

THE READING AND SPELLING OF MORPHOLOGICALLY COMPLEX WORDS BY ADULTS, CHILDREN, AND DYSLEXIC CHILDREN

3.1 The nature of morphology

The English language is morpho-phonetic, so it is important to know how the written forms of morphologically complex words are processed. It is estimated that 60% of new words acquired by school-age children in English stem from the inflection, derivation or compounding of morphemes (Nagy & Anderson, 1984).

A morpheme is the smallest unit of meaning in a language, and words comprise one or more morphemes. Morphemes that can stand alone, and therefore constitute a word, are called 'free' morphemes (e.g., *cat, danger, table*). Two 'free' morphemes may be joined to create a new, compound word, such as *black* + *board* = *blackboard.*

A second category of morphemes are 'bound', because they do not constitute a word unless they are attached to a free morpheme. There are two kinds of affixes: prefixes, which occur before a free morpheme (i.e., *un-*, *re-*, *dis-*, *in-*), and suffixes, which occur after the free morpheme. There are two kinds of suffixes: derivational and inflectional. Derivational suffixes can change the class of a word (e.g., the noun *happy* with the suffix -*ness* becomes the adverb *happiness),* or its meaning (e.g., *un* + *clear* becomes *unclear*). Inflectional suffixes modify rather than change a word's meaning, and indicate tense (e.g., *walk* + *ed* = *walked*), person (e.g., they *run* > she *runs*) and number (e.g., one *dog*/two *dogs*). In many languages, such as French, inflectional morphemes also indicate gender (e.g., il est *vieux,* elle est *vieille* [he is old, she is old]) and subject-adjective agreement (e.g., la *grande* maison, le *grand* chien [the big house, the big dog]).

3.2 Morphological development in spoken language

In spoken language, morphological development proceeds in stages. For most children, the use of morphologically complex words occurs soon after they can produce two-morpheme utterances (e.g., "me want"), at around the age of 2 years. Brown and Cazden (1968) analysed the utterances of three children and found that morphemes appeared in a particular order (see Table 3.1). These stages have been supported by larger studies (de Villiers & de Villiers, 1973).

Table 3.1. Average Order of Acquisition of Fourteen Morphemes
(from Tager-Flusberg, 1997)

1	Present progressing	singing; playing
2/3	Prepositions	in the cup; on the floor
4	Plural	books; dolls
5	Irregular Past tense	broke; went
6	Possessive	mummy's chair; Susie's teddy
7	Copula uncontractible	this is my book
8	Articles	the teddy; a table
9	Regular past tense	walked; played
10	Third person present tense regular	he climbs; mummy cooks
11	Third person present tense irregular	John has three cookies
12	Auxillary uncontractible	she was going to school; do you like me?
13	Copula contractible	I'm happy; you are special
14	Auxillary contractible	mummy's shopping

What determines these stages? Brown (1973) rated the frequency of morphemes in the children's parents' speech and found no correlation, so concluded that the stages are not an artefact of environmental factors. Rather, the sequence appears to be related to the linguistic complexity of the morphemes. He computed linguistic complexity as the cumulative frequency of the semantic (i.e., how many meanings are encoded in the morpheme) and syntactic (i.e., the number of rules required for the morpheme) complexity of the morpheme. Using this formula, Brown acknowledged that not all morphemes could be ordered in such a way. However, for those that can, complexity can account for age of acquisition. For example, the plural contains information about number, so plural morphemes are less complex than third person present tense, which contains information about tense and number.

One of the earliest forms of morphological processing in children is the ability to inflect words. Their first use of inflections is the regular pluralisation of nouns (i.e., the use of –s). At around the age of 2 years, children will apply *–s* endings to irregular plural forms, so may say 'look at sheeps' and 'where childrens gone?', though such errors are not as common as one would think, occurring in only around 10% of children (Pinker & Prince, 1992).

The ability to allocate the correct inflection for regular and irregular verbs comes later. It has been suggested by Pinker and colleagues that children first encode all inflected verbs as whole lexical items (Marcus, Pinker, Ullman, Hallander, Rosen, & Xu, 1992; Pinker & Prince, 1992). Children then go on to deal with irregular and regular verbs in different ways: irregular verbs continue to be stored as wholes, but regular verbs are stored as a root word, and inflections are processed by a rule-governed mechanism. This allows more storage in the memory system. The restriction of regular verb inflections to regular verbs is largely in place by the age of five (Berko, 1958; Brown, 1973; de Villiers & de Villiers, 1973).

Other theorists have proposed that inflectional processing does not occur through a rule based system, but rather through the building up of connections between morphemes (Rumelhart & McClelland, 1986).

In English, it appears that inflectional morphology is acquired slowly in a piecemeal fashion; the child who utters "me playing" for the first time does not know that *-ing* can be applied to all present continuous verbs. Pine and Lieven (1997) suggest children acquire rote-learned phrases that are slowly slotted into a framework for grammar. In other languages, particularly highly inflected ones, like Italian and Spanish, it has been suggested that children's acquisition of inflectional morphology is rapid (Hyams, 1986b). However, closer analysis of children's use of inflections in Italian and Spanish shows that, although these children may produce inflected forms early, sometimes as young as 18 months, full mastery takes much longer and is in line with the rate at which English speaking children acquire inflectional morphology (Pizzuto & Casselli, 1992; Sebastián & Soto, Gathercole, 2001).

Children's production of derived forms comes later. By around the age of five, they can produce derivations that are phonetically and semantically transparent (e.g., *bake-baker*). More complex phonological shifts from base to derived forms, such as, *divide-division* are too difficult for children when they start school, and tend to occur at around the age of eight (Jones, 1991).

The acquisition of inflections and derivations in spoken language is probably implicit. However, the ability to reflect upon and articulate morphological relationships between words is explicit, and could be assessed by asking children questions such as, 'do you think the words *male* and *malicious* are related to each other?' (e.g., Derwing, 1976). It may well be that such knowledge is developed through children's experiences of literacy. For example, the morphological relationships between *heal-healthy*, and *divide-division* are emphasised in print due to orthographic similarities (Fowler & Liberman, 1995). As with phonological awareness, some morphological skills are in place before children learn to read and spell, while others may occur as a consequence of learning to read.

3.3 Models of word recognition for morphologically complex words

A central question in reading and spelling research has been whether words are represented in the lexicon as wholes or as morphemic units, as was first suggested by Murrell and Morton (1974). For example, do words like *dog, dogs, dogging* and *dogged* have separate representations or is only the root word, *dog,* stored and are the related words processed by rule?

Castles, Coltheart, Savage, Bates, and Reid (1996) point out that if lexical entries were stored as morphemes, this would lead to great economy of storage, because only one representation would be needed for a family of morphologically related words, such as *sing, singing, singer, singers, sang.* In morphologically rich languages, like Italian, in which verbs may contain up to 60 infections, the economy of storage would be very large indeed.

In addition, a rule-based system allows individuals to understand new combinations of a morpheme. The system needs to be productive so that once a stem and suffix are known, individuals can understand new words like *elephants* for the first time. Also, to understand the meaning of sentences, some form of morphological analysis is needed.

However, the economies of storage to be gained by a rule-based system are counteracted by the cost of heavy processing demands.

Models of how morphologically complex words are stored in the lexicon have traditionally adopted polar positions: whole word approaches argue that each word, no matter what its morphological complexity, has a separate representation in the lexicon (e.g., Butterworth, 1983; Bybee, 1995; Colé, Beauvillain, & Segui, 1989; Emmorey, 1989; Lukatela, Gligorijevic & Kostic, 1980; Rubin, Becker, & Freeman, 1979; Segui & Zubizarreta, 1985). Conversely, decomposed models suggest each word is parsed into its morphological components. Within decomposed models, the level at which decomposition occurs varies: some argue the decomposition occurs prelexically (Taft & Forster, 1975), whereas others suggest it occurs at morpho-semantic levels (Drews & Zweitserlood, 1995; Grainger, Colé, & Segui, 1991; Schreuder, Grendel, Poulisse, Roelofs & Van de Voort, 1990; Schriefers, Frederici, & Graetz, 1992; Schrieders, Zweitserlood, & Roelofs, 1991). An intermediary approach is that decomposition occurs at both prelexical and morpho-semantic levels (Allen & Badecker, 2001; Badecker, & Caramazza, 1991; Burani, Salmaso, & Caramazza, 1984; Caramazza, Laudanna, & Romani, 1988; Stanners, Neiser, Harmon, & Hall, 1979; Sternberger & MacWhinney, 1986).

Due to the fact that more research on morphological processing has focused on inflectional endings, rather than derivations and compounds, the majority of these models have been formulated to account for data on inflectional morphology, though some could plausibly be extended to deal with derivation and compounding.

Whole word processing models

These models maintain that each word is stored as an independent lexical representation and that no morphological structure is encoded in these representations. The lexicon comprises a full list of previously encountered words, and morphological information related to a lexical form is part of its semantic information. For example, the representation *walked* is encoded alongside information about it being a past tense form of the verb *walk*, so the words *walk* and *walked* are both recognised by direct lexical access.

In Bybee's connectionist model (1995), complex forms are stored in an associative network and recurring phonological and semantic patterns are presented as links between units, so morphemes have no independent status. For example, a word like *walking* connects with *walked* because they share the root *walk*, but it also connects with words like *shouting* because they share the *-ing* ending. These multiple connections lead to generalisations that allow apparent rule-like behaviour to emerge.

In Bybee's model, activation levels are set on the basis of lexical strength (i.e., a word's frequency) and lexical connections (i.e., the number of words with which it is connected). A word with few connections to other words should have higher whole word lexical strength than words with many connections to other words. An example of this would be the difference between nouns and verbs. In English, a noun has two lexical representations, the singular (e.g., *table*) and plural (e.g., *tables*). Conversely, most verbs would have four lexical representations (e.g., *walk, walks, walked, walking*). Consequently, whole word frequency effects should be more common for nouns than verbs.

So how do these whole-word representation models account for our ability to recognise new words like *hugable* and *emailed*? According to these models, when the input's form does not match any representation in the lexicon, independent knowledge, stored elsewhere in our brains, becomes activated. This independent knowledge includes knowledge of bases and affixes in the language, and would allow for the decomposition and comprehension of words like *emailed.*

A further problem concerns how we are able to reject illegal forms like *dancinged.* A parsing system would not be enough to reject this form, so a stem and affix compatibility process would need to be activated.

Decomposed Representation Models

(i) Prelexical decomposition

The most representative of the fully decomposed models of lexical processing is the one suggested by Taft and Forster (1975). According to these authors, the stem of a word constitutes the lexical entry of affixed words, so a word like *reporter* would be presented as stem (*port*) + prefix (*re*) + suffix (*er*). This affix stripping occurs pre-lexically.

There are some problems with this view, which will be discussed in relation to inflections. In English, inflections pertain to verb endings and plural nouns. While Taft's proposed system might easily deal with the recognition of words like *walked* and *tables* by decomposition (i.e., *walked* = *walk* + past tense ending *ed*; *tables* = *table* + plural ending *s*), it is hard to see how the same system could cope with irregular inflections such as *seek* → *sought*, *child* → *children*, and *die*→ *dice*. Even regular inflections of past tense verbs present problems. How could a parser deal with transformations such as *clap*→ *clapped* and *refer*→ *referred* in which a consonant is added at the morpheme boundary. If they were parsed into stem and affix, the system would be presented with unidentifiable units, such as *clap* + *ped* or *clapp* + *ed*. A converse problem concerns removal of vowels at a morpheme boundary, like *moved* (e.g., *mov* + *ed* or *move* + *d*).

In recent formulations of this model (e.g., Taft, 1991; Taft & Zhu, 1995), morphemes are represented as units within a hierarchical activation system and are activated whenever congruent orthographic information is contained within a letter string. The activation of these morpheme units then passes to units representing whole words. Therefore, a morphologically complex word is not actively decomposed prior to lexical access, but is always accessed through activation of its morphemes.

(ii) Decomposition at morpho-semantic levels

These models suggest that words are not decomposed at the level of form but in higher order processes which govern semantic and syntactic judgements. An example of this type of approach would be the one provided by Schreuder and Baayen (1995). The Dutch word *boek* (book) and its plural form *boeken* each have an independent lexical representation. However, at later processing levels, they converge because the forms *boek* and *boeken* share a common processing node which represents the semantic and syntactic information about the word *boek*, but *boeken* is also processed by an abstract node for plurals, which it shares with other plural nouns. In some ways, this converges with Bybee's account of connections between words.

(iii) Intermediary approaches

A number of theories suggest that decomposition can occur at prelexical and higher order levels. The most representative of these are the Augmented Addressed Morphology Model

(AMM), presented by Caramazza and colleagues (Caramazza et al., 1988; Laudanna, Badecker, & Caramazza., 1992), and the multi-level decompositional model of Allen and Badecker (1999). These models assume that the word processing system functions in the most transparent way possible; processing relies only on information carried explicitly in the surface form of the stimulus.

In these models, if the whole word form has a relatively high frequency, it simultaneously activates both its whole word representation and the units corresponding to the morphemes that comprise the word. Activation of whole-word lexical access is faster than the activation of the morphemic constituents of the word.

Lexical representations for regularly inflected forms, and novel and unfamiliar morphologically complex words (i.e., when the frequency of the stem is higher than the frequency of a derived or inflected form) are accessed through morpheme-sized units. All irregular forms (e.g., *go* and *went*) are represented as whole words, as there is no common base that can be recovered from the input stimulus, but they are mapped onto morpheme based representations at an abstract morpho-semantic level.

Word recognition occurs on the basis of similarity between the stimulus and a lexical representation. The input unit has to fulfil a number of criteria in order to activate a given lexical unit. Firstly, the stimulus must be orthographically identical to the lexical unit. Secondly, it must satisfy conditions related to the distribution of the lexical units in the language. Chialant and Caramazza (1995) give the example of the Italian suffix -*ire*. This suffix only occurs at the end of a word so would never be preceded by a word boundary. This can be represented as *–ire#*. However, the word *ire* (anger, plural) can occur in isolation, so should be represented as being flanked by two word boundaries, such as #*ire*#. When a word like *partire* is presented, the access unit –*ire*# would be activated but #*ire*# would not.

Once a lexical unit has been activated, its grammatical information is made available. This includes information about the combinatory properties of constituent morphemes and grammatical class information.

3.4 Empirical research on how skilled adults process morphologically complex words

There are two strands of research that impact upon debates concerning the processing of morphologically complex words: research on skilled adults and research on adults with neurological impairment.

Studies investigating morphological complexity are varied in terms of their scope. Aside from the basic question of whether decomposition occurs at all, there are studies to assess the level at which decomposition takes place, and studies to address whether decomposition processes vary for the three types of morphologically complex words (inflected, derived, and compounded). Within each of these three areas of morphological processing, studies have been formulated to assess whether issues such as transparency and productivity affect the relationship between a root word and its morphological relatives. These terms will be explained briefly because they are necessary when interpreting the data that will be reviewed later in this section.

Transparency refers to the clarity of the relationship between a monomorphemic word and its morphologically complex relations in terms of orthography and pronunciation. For example, the relationship between *walk-walked* is transparent, and therefore regular, whereas the link between *buy-bought* is opaque, and therefore irregular.

Productivity refers to the ability of a morpheme to create new words. Some suffixes are highly productive (e.g., *-ish*, and *-ness*), in that they can be added to many words to create new ones (e.g., *darkness*, *foolish*) whereas others are not (e.g., *-ity*); words containing productive morphemes more likely candidates for decompositional processes.

This review will generally focus on studies that address the level at which decomposition occurs for inflection and, to a lesser extent, derivation, and will include studies conducted in English, Italian, and French[1]. There are broadly three types of data concerning how skilled readers and spellers process morphologically complex words: root frequency effects; morphological priming; and non-word decomposition.

(i) Root frequency

When researchers refer to word frequency, they are generally talking about a word's surface frequency (i.e., the frequency with which the word occurs as a complete unit). However, recognition time could also be affected by the word's root frequency (i.e., the cumulative frequency of the root and all it's inflected and derived forms, such as *want, wants, wanted, wanting)*.

Studies investigating inflected words have found that root frequency is a better predictor of lexical decision times than surface frequency. A classic example reported by Taft (1979) is that of *sized* and *raked*; these words have similar surface frequencies in English, but different root frequencies; *size* is more frequent than *rake*. Consequently, if

[1] The data presented will lead to a relatively limited picture, as morphological processes do vary depending on language (see Bentin & Frost, 1995 for studies on Hebrew; and Taft & Zhu, 1995, for studies in Chinese), and there is extensive work on derivations and compounding which will not be included. For a more thorough review of morphological decomposition,see Anderson (1992) and Allen and Badecker (2001).

words are decomposed before lexical access, *sized* should be read more quickly than *raked*. It is.

The picture is less clear for derived words because whereas inflections do not change the syntactic category of their base forms, derivations alter word-class membership. For instance, the verb *to scare*, remains a verb when it is inflected (*scared, scares, scaring*), and the noun *a scare* remains a noun when it becomes plural, for example, *(health) scares*. However, when the derviational suffix *y* is added, *scare* becomes *scary* - an adjective. Could this word class effect impact on the likelihood of derived forms being decomposed?

A French study by Colé, Segui, and Taft (1997) compared lexical decision times to words that were matched on surface frequency but differed on the cumulative frequency of their derived forms. They found that root words with high cumulative frequency for derived forms, such as *taille* (cutting), whose derivations are *tailleur* (tailor), and *tailler* (to cut), took longer to read than words with low cumulative frequency, such as *cire* (wax), which has the derivations *cirer* (to wax), and *cireur* (polisher). This is the opposite of what occurs with inflected forms. This effect interacted with the root word's surface frequency. Words whose surface frequency was greater than their morphemic frequency (i.e., the cumulative frequency of all its derivationally related words not including the frequency of the free standing word form), were read more quickly than words whose surface frequency was lower than their morphemic frequency. Therefore, a word's many derived forms will inhibit the reading of a root word with high cumulative frequency, but only when the combined sum of these derived forms has greater frequency than the stem itself. This suggests that derivations are handled differently from inflections in terms of morphological decomposition.

Whilst the root frequency effect has been taken as evidence for the existence of decompostional procedures in word recognition, Allen and Badecker (2001) point out these findings could be interpreted through whole word models. For instance, in Bybee's model, in which morphologically linked words are connected, the activation of the word *size* may send activation to the past tense *sized* (as well as *sizing*), thus raising its resting level of activation. Consequently, recognition of morphologically complex words stored as whole words would be quicker if they were semantically related to frequent stems. Support for this view comes from studies that report faster response times to irregularly inflected words, like *bought*, which are linked to high frequency stems, like *buy*. As fully decomposed models are unable to account for how *bought* might be decomposed as *bought* → *buy* + *past tense*, this finding tends to favour the view that some words, certainly irregular verb inflections and irregular noun plurals, are represented as wholes in the lexicon.

(ii) Morphological priming

Lexical decision latencies are faster when a word (e.g., *cars*) is preceded by its morphological stem (e.g., *car*) than when it is preceded by an orthographically related word (e.g., *card*) (Stanners et al., 1979). This 'morphological priming' effect has been observed in a number of languages and remains robust whether mode of presentation is auditory, visual or auditory-to-visual. Furthermore, it appears that semantically unrelated/orthographically similar primes lead to negative inhibition (Laudanna, Badecker, & Caramazza, 1989).

These data suggest that lexical representations are stored in a decomposed manner, but they do not confirm whether this decomposition is at the level of form or the abstract morpho-semantic level (Allen & Badecker, 2001).

(iii) Non-word structure

Experiments employing non-words that are decomposed in various ways have yielded the most robust data in support of the morphological decomposition hypothesis. Taft and Foster (1975, exp. 3) found non-words comprised of an illegally combined stem and prefix, like *dejuvenate* (*-juvenate* < *rejuvenate*) were rejected more slowly than non-words comprised of a prefix and pseudo-stem like *depertoire* (**pertoire* < *repertoire*). However, their study was criticised by Manelis and Tharp (1977) because they did not match the real stem and the pseudo-stem for cumulative frequency.

A better study, by Caramazza et al. (1988), matched stems and pseudo-stems for cumulative frequency. They found Italian subjects were slower and produced more errors when rejecting non-words that could be parsed into actual root and affixes (e.g., *cant-evi*; [walk-est]) than when rejecting non-words that contained a pseudo-root (e.g., *canz-evi*; [wilk-est]) or a pseudo-suffix (e.g., *cant-ovi*; [walk-ost]).

As lexical decision time differences for non-words cannot be accounted for by whole word representation hypotheses, these data do favour a decomposed hypothesis but, again, such data may be interpreted through models which predict decomposition at a higher level.

To address this issue, Caramazza et al. (1988, experiment 3) carried out a further experiment which involved combining real verb stems with real, but incorrectly placed, verb suffixes. Irregular verbs in Italian have two stems: the stem of the infinitive and the stem of the past participle. For example, the verb *correre* (to run), has a major stem, *corr*, from the infinitive, and a minor stem, *cors*, from the past participle, 2^{nd} conjunction. They combined these stems with affixes that would normally be attached to regular verbs but never to irregular verbs: *uto* (past participle 2^{nd} conjugation) and *ito* (past participle 3^{rd} conjugation). By combining the stems and affixes, three types of non-words were produced: irregular major 2^{nd} conjunction stem with an affix belonging to the correct conjugation but not used with irregular verbs, like *corruto*; an irregular minor second junction stem with an affix belonging to the correct conjunction but not used with irregular verbs, like *corsuto*, and an irregular major 2^{nd} conjunction stem with an affix belonging to the 3^{rd} conjunction, *corrito*.

Caramazza et al. (1988) reasoned that if words were parsed at a semantic level, there should be no difference in time taken to reject the three types of non-words because: (a) the stems were all semantically identical, except for one feature which indicated the past tense, and (b) they all orthographically corresponded to real stems which shared the same frequency. However, if the non-words were parsed at the level of form, the one which is more word-like (i.e., *corr-uto*), in terms of its stem-affix compatibility, should take longer to reject. This is what they found.

3.5 Morphological processing in neurologically impaired adults

Studies of individuals with acquired language disorders (i.e., disorders resulting from neurological damage) suggest that many of their errors in written and spoken language involve some element of morphological impairment. Such errors include instances where the root morpheme is preserved but affixes are added (e.g., *walk* → *walked*), deleted (e.g., *baker* → *bake*), or substituted (e.g., *runner* → *running*).

However, these errors cannot be taken at face value as evidence of a discrete morphological processing system, because they could plausibly be accounted for as epiphenomena of impairments to other aspects of language processing. Errors like *walk* → *walking* could be visual errors, that is, the inability to match orthographic elements of a presented stimulus to stored representations. They could equally be semantic errors, in which the stimulus activates a word related to the stimulus rather than the word itself. Finally, these errors could be due to some problem with peripheral phonological output processes for reading aloud, and with peripheral orthographic output processes in spelling.

Researchers have developed a number of tasks that enable visual, semantic and phonological errors to be segregated from morphological errors. Furthermore, by presenting tasks in different modalities (i.e., written input, picture naming and matching, and spoken input), it is possible to locate the source of a deficit fairly precisely.

The framework I will adopt in describing cases of morphological deficit is borrowed from Coltheart (1985). He suggests that reading, spelling, and naming errors may be conceptualised as impairments at input (orthographic and phonological), central (semantic) and output (orthographic and phonological). If words are processed via morphological decomposition rather than as whole words, it is plausible to assume that each of these modules would have a morphological processing component within them.

(i) Input

Orthographic input lexicon

A representative case of impairment at the level of the orthographic input lexicon is that of QN (Castles et al., 1996). QN, a highly educated 57-year-old university lecturer, suffered a CVA that resulted in cortical and sub-cortical damage to the left middle cerebral artery. To unravel the possibility that his morphological errors may have been visual, Castles et al. presented him with Funnell's (1987) set of 32 suffixed and 32 pseudo-suffixed words (e.g., *corner, irony, topic,* and *tally*). The two lists were matched for word frequency and imageability, and the stems of both sets of words were matched for frequency. If morphological errors are in fact visual, patients should make equal numbers of errors on both sets of words. QN made more errors on suffixed words. When subsequently given 45 suffixed items (15 derivational suffixes, 15 irregular inflections, and 15 regular inflections), matched to 45 matched one-morpheme words to read, he made errors on the derivations and regular inflections, but not on the irregular inflections, compared to the control list. This ruled out the possibility that his morphological impairment was visually mediated.

What about prefixed words? Interestingly, there was no difference between his performance on prefixed (e.g., *dislike, unable*) and pseudo-prefixed words (e.g., *dismay, refuse*), although in spontaneous reading he read pseudo-prefixed words more successfully.

Castles et al. found QN's erratic reading of pseudo-prefixed words difficult to explain; they suggested that the presentation of the pseudo-prefixed words alongside so many prefixed words may have lead to task anxiety, resulting in poorer than normal reading of monomorphemic words.

QN's comprehension of suffixed words was assessed; he was presented with 23 suffixed nouns that referred to a person or occupation (e.g., *dancer, builder, optician*). Three types of foil were generated: morphological foils, which were morphologically related to the target word but did not refer to a person (e.g., *dancing, optical, building*); visual foils, which were highly visually similar to the target but morphologically and semantically unrelated to it (e.g., *danger, opinion, boulder*); and semantic foils, which had a similar meaning to the target word but which bore no visual or morphological resemblance to it (e.g., *ballet, spectacles, house*). QN was required to read the list silently and say "yes" if the word referred to a person or occupation and "no" if it did not. He made more errors in the morphological foil condition. As he spontaneously read out many of the words he was given, the researchers detected that 5/9 of his errors were due to morphological substitutions (e.g., *painter → painting, miner→ mining*). When this comprehension task was presented auditorily, he made only two errors.

To summarise, QN's morphological deficit affected only written language. His performance on the spoken version of the comprehension task suggests his problems were not semantic and his phonological input lexicon was intact. His ability to read pseudo-prefixed words suggested that the phonological output lexicon was also intact. As his writing was abolished, it was not possible to assess whether his orthographic output lexicon was damaged. These findings lead Castles et al. (1996) to suggest that QN's morphological deficit was located in the orthographic input lexicon. The theoretical implications of his case are: (a) regularly inflected and derived morphologically complex words may be stored as morphemes, and (b) irregular inflections may be stored as whole words, and (c) prefixed words may be dealt with differently from suffixed words.

(ii) Semantic

At the semantic level, a morphological processing deficit would affect knowledge of tense agreement, plural agreement and, in some languages, gender agreement. Morphological processing in the semantic system would be linked to syntactic awareness, as well as knowledge of the legality of certain words within a sentence structure. If the semantic system mediates all input and output, then damage here would lead to morphological errors on all tasks. However, if the damage to the semantic system were extensive, the patient would be too impaired to investigate. Consequently, studies have only been conducted on patients who exhibit partial semantic damage in relation to morphology.

A good example is that of DE (Tyler, 1992; Tyler & Cobb, 1988; Tyler & Ostrin, 1994). In unimpaired populations, the presence of a linguistic anomaly slows down the ability to indicate when they have heard a target word in a sentence. For example, identification of the target word *cook* is delayed when it is preceded by an illegal stem-affix combination (e.g., He was the most *wastely* cook) than when preceded by a legal one (e.g., He was the most *wasteful* cook). DE was not susceptible to this effect; he did not take longer to identify words when inappropriate inflections (e.g., detecting *cause* in *It often causing pain*), derivations (e.g., detecting *bumps* in *to flatly bumps*), or illegal stem-derivational affixes were used (e.g., to *flatment* bumps). However, he did take longer to identify target words when stems that usually take an inflectional affix were combined with a derivational affix (e.g., *causely, mixly*).

What does this show? DE's performance shows that inflectional and derivational processing are dissociated, at least at the semantic level.

(iii) Output

At output, morphological processing is involved in assembling constituent morphemes into a whole word representation prior to articulation or writing.

Phonological output

A case of damage to the phonological output system is that of SJD (Badecker & Caramazza, 1991). SJD, a 47-year-old female graduate, suffered a left hemisphere stroke that resulted in spoken and written language deficits. She performed well on a lexical decision task, which implied that her orthographic input lexicon was functioning. However, on reading aloud, she produced many morphological (e.g., *bowled* → *bowling*) and visual/phonological errors (e.g., *mallard*→ *mallet*). In order to determine whether these errors were due to a general phonological output impairment, she was given a list of affixed words (e.g., *links; bowled*) and one-morpheme homophones (e.g., *lynx; bold*). She made many more errors on the affixed targets. SJD also made morphological paraphasias in word and non-word repetition. Similarly, when shown or told a word and asked to generate a sentence containing that word, she made predominately morphological errors (e.g., *darken* → *It gets darkly after eight*), as well as semantic errors (e.g., *boy* → *the boy fetched to the dog*). In spelling to dictation, she produced phonetically implausible spellings, such as PIM for *picnic*, and semantic errors, such as TEACHING for *training*.

On the basis of her performance, Badecker and Caramazza (1991) concluded that her impairment could be located in the phonological output lexicon. SJD produced phonological errors, which suggests that the phonological processing element of this system was impaired. In some cases, this led to the production of words that were phonologically similar to the target, and in others, when the target could not activate a phonological neighbour, non-words were generated. But her morphological errors cannot be interpreted as phonological errors, because, in addition to more errors on affixed words compared to their homophones, she also generated illegal stem-affix combinations (e.g., *walkness*). SJD's case shows that the phonological output lexicon must contain some processing which deals exclusively with the assembly of morphologically complex words.

Orthographic output

A case of impairment to the orthographic output system is that of BH (Badecker, Rapp, & Caramazza, 1996). BH was a highly educated 45-year-old male who suffered damage to his right frontoparietal and left frontal lobe after an aeroplane accident. His ability to produce audible speech was very impaired and he preferred to communicate in writing. His memory problems made it difficult for him to follow task instructions, but the researchers were able to establish that his syntactic comprehension abilities were largely intact. For instance, he could write down the ending of sentences using the correct tense and agreement (e.g., *She drank four... "bottles of alcohol"*), and although he did produce neologisms, he managed to write the correct inflection (e.g., *Just a minute ago.... "we turked everything"*).

BH could not spell words lexically, so used a sub-lexical route (e.g., *census* → SENSIS; *benign* → BENINE). However, for morphologically complex words, there was a difference between his spelling of stems and affixes. While stems could not be retrieved lexically, it appeared that affixes could, so he spelled *surfed* as SOURPHED (not SOURPT), and *cabooses* as CABUSES (not CABUSIZ). His preservation of suffixes could not be explained as a general tendency to produce the most likely phonology-to-orthography mapping (i.e. /t/ → *ed*) because he would spell *wolfed* as WOULPHED but *concoct* as CONCAUCT (not CONCAUKED). Nor could his spelling be accounted for as a tendency to maintain the correct ending of a word, because for matched uninflected words he made errors at the ends of words, like RETHMICK for *rhythmic*, and CORDD for *chord*.

Badecker et al. concluded that BH's performance was due to impairment of the orthographic output lexicon. In BH's case, some morphemes, notably affixes, were represented correctly and fed down to a limited capacity output buffer, but other morphemes, notably stems, were not represented in the orthographic output lexicon so had to be generated by sub-lexical processes.

Indirect evidence for the storage of complex words as morpheme sized units in the orthographic output lexicon comes from a study of patient DH (Badecker, Hillis and Caramazza, 1991). DH fared better when spelling morphologically complex words; the likelihood of his making an error increased towards the end of a morpheme, but dropped to baseline at the start of a new morpheme (e.g., *snarling*→ SNALING; *discovery* → DISCORY). Conversely, on matched monosyllabic words, errors were more likely to occur at the end of the word (e.g., *brisk* →BRSST).

There was an interesting dissociation in DH's performance on derived words. He was better at spelling suffixes for productively derived words like *teacher* and *darkness*, but not for non-productively derived words like *personal* and *difference*; he was as likely to make an error on these types of words as on monomorphemic words.

Badecker et al. concluded that DH's performance was due to impairment of the graphemic buffer – a limited capacity store of to-be-written words. Words are fed into this store from either the orthographic output lexicon or the sub-lexical route. For morphologically complex words, the morpheme units are fed successively into the store, first the stem, then the suffix. The longer a word remains in the store, the more likely it is that its representation will degrade. In DH's case, representations in this store degraded very rapidly, so by the time he got to the end of a word, he could not access the correct letter sequence; consequently he made more errors at the end of monomorphemic words and stems. However, the suffix, as the most recently primed unit, was spelled correctly much of the time. This lends weight to the argument that the orthographic output lexicon stores words in morpheme sized units. DH's performance also suggests that non-productive derived forms may be represented differently from productive derived forms; the former are represented as whole words but the latter are stored as morphemes.

Summary of adult data

Models of how adults process morphemically complex words have historically diverged between those that place the unit of lexical access at the morphemic level at one extreme and at the whole word level at the other. More recent accounts fall between these two positions, and this intermediate approach is best able to account for the data that has been reported from studies on normal and neurologically impaired adults. These data suggest that:

- words are stored as morphemes at input and output lexicons.

- some words are more likely to be decomposed at the level of form than others. These are principally words that are transparently related to their morphological neighbours: notably (a) regular verbs (i.e. whose past tense form is +*ed*); (b) regular nouns (i.e. that pluralise with +*s*) inflections; (c) *perhaps* regular, productive and transparent derivations (i.e. derivations that do not alter the orthography or pronunciation of the base (e.g., *walk-walker*).
- Some words are stored as wholes in the lexicon, but their morphemic units must be acknowledged at some level in order for comprehension to occur. This level is most probably the morpho-semantic/syntactic level. Words dealt with in this way are: (a) words opaquely related to their morphological neighbours (i.e., irregular verb and noun inflections), and (b) *perhaps* derivations which do not share orthography of the base form (e.g., *happy-happily*), or phonology of the base form (e.g., *equal-equality*), or both (e.g., *decide-decision*).
- The likelihood of a word being decomposed depends upon a number of other factors, such as the frequency of the root form compared to the frequency of the free form. This effect is differential for inflections and derivations.

3.6 The role of morphology in literacy acquisition

In comparison to the large body of work emphasising phonology's role in literacy acquisition, the role of morphology has received considerably less attention. This disparity could be due to a general assumption that morphological awareness does not exert much influence on reading and spelling development until later on. For instance, morphological knowledge constitutes some of the higher order linguistic rules needed for what Frith

(1985) refers to as the 'orthographic stage'. In reading, morphological awareness allows us to understand invented words like, *unputdownable* and *moreish*. In spelling, appreciation of morphological relations helps spellers to remember silent letters in words (e.g., *condemn-condemnation, bomb-bombastic*), though, of course, it also leads to common spelling errors (e.g., *proceed-proceedure*).

But does morphology play a role in reading and spelling before children reach the 'orthographic stage'? In many ways this is a difficult issue to address because, unlike phonology, which can be assessed without recourse to wider linguistic skills such as semantics and syntax, morphological awareness is very difficult, if not impossible, to isolate from other language skills. That is, when one assesses a child's morphological awareness, one is also assessing their comprehension of grammatical class, syntax, and semantics. To further complicate the issue, morphology also relates to phonology, because morphological derivations which are phonologically transparent (e.g., *teach-teacher*) are easier than those which are more opaque (e.g., *revise-revision*) (Carlisle, 1995).

Morphology and Reading

The general finding has been that better readers perform well on tasks of morphological awareness in spoken language. Brittain (1970) showed a correlation between reading ability and performance on the Berko (1958) task, independent of intelligence. However, correlational data does not specify the direction of a relationship.

A study using regression analyses by Carlisle & Nomanbhoy (1993) found after variance related to phonological awareness was accounted for, the morphological awareness of 1st graders (aged 6 years) made a small but significant contribution to variance in word reading.

In a longitudinal study, Carlisle (1995) investigated the extent to which morphological awareness exerts an independent influence on reading acquisition. She assessed children in kindergarten and then in the 1st grade on measures of morphological awareness and correlated these scores to their reading performance in 2nd grade.

Two morphological awareness tasks were used. The first was a production task in which children were given a base word and a sentence with the last word missing. They were asked to finish the sentence with a form of the word they had been given initially (e.g., *Farm. My uncle is a ________*). One third of these were inflected forms, a third were derived forms with transparent relations (e.g., *drive-driver*) and the remainder were derived forms with phonological changes (e.g., *explode-explosion*). The second task was one of morphological judgement, in which children had to decide if a statement made sense or was silly; some were correct (e.g., *a person who teaches is a teacher*) and some were false (e.g., *a person who makes dolls is a dollar*). The children were also tested for phonological awareness, reading accuracy and comprehension, and language knowledge.

Carlisle found that any effects of morphological production in kindergarten could be accounted for by language knowledge, so morphological awareness did not 'predict' reading in the 2nd grade. However, their scores on the morphological production task in the 1st grade provided a greater contribution to reading comprehension in the second grade than phonological skills. Furthermore, their production scores also made an independent contribution (along with phonological awareness) to single word reading.

It seems logical that morphological awareness should exert an influence on reading comprehension, as morphological awareness is inextricably linked to syntax, which is crucial in sentence comprehension. However, its effect on word analysis or word accuracy is more unexpected, and Carlisle was unable, on the basis of her data, to provide an explanation for it. It could be that text reading leads to enhanced ability to use sentential context to learn new words, which in turn causes an increase in the child's sight word vocabulary.

Carlisle's findings have been supported by recent studies which have shown that morphological awareness makes an independent contribution to decoding skills once phonological skills have been taken into account (Mahony, Singson, & Mann, 2000). Furthermore, the importance of morphological skills for reading ability increases throughout the higher primary school years (Singson, Mahony, & Mann, 2000).

Morphology and Spelling

The use of morphological knowledge in children's early spelling attempts is difficult to assess through interpretation of their spontaneous writing because, in English pronunciation, many of the morphologically complex words children are likely to encounter in their first few years of schooling are reasonably phonologically regular (e.g. *waited, dirty, sadly*), so correct spellings of these words could be due to phonic skills rather than morphological skills.

However, in American English pronunciation, the presence of /t/ sound at a syllable boundary, such as when a suffix is added to words ending in '*t*', creates a flap, a quick flick of the tongue against the roof of the mouth, so although *wait* and *dirt*, are pronounced /weit/ and /det/, *waited* and *dirty* are pronounced /weidid/ and /dedi/.

Treiman, Cassar and Zukowski (1994) reasoned that if American children ignore morphological relations, they should misspell suffixed words whose root word ends in '*t*' with the same frequency with which they misspell one-morpheme, two syllable words which contain '*t*' at the syllable boundary, such as *duty* and *attic*. They examined the ability of children to spell: root words ending in '*t*' (e.g., *wait, dirt*) and '*d*' (e.g., *loud*); suffixed words with a '*t*' flap (e.g., *waited, dirty*) and '*d*' flap (e.g., *louder*); and one-morpheme words with a '*t*' flap (e.g., *duty, attic*) and '*d*' flap (e.g., *sturdy*). In their first study, 1st and 2nd grade children had to spell the words and in a second study, which included a group of kindergarteners, they were given the words on paper and asked to put in the missing '*t*' or '*d*'. Results from the two studies showed that although young children don't use morphological information to its full extent in spelling, they do use it; kindergarteners and first graders were more likely to spell the '*t*' flap correctly for two-morpheme words compared to one-morpheme words (i.e., spell *dirty* as *dirty* but *duty* as *dudy*). The second graders, whose overall level of performance was high, did not show this difference. Overall, the children did better on the '*d*' flap words because there was a close correspondence between sound and orthographic representation.

In another study, Treiman and Cassar (1996) looked at children's spelling of final consonant clusters. Generally, children tend to leave out the first consonant of a final consonant cluster (e.g., *horse* → HOS). They compared children's ability to spell one-morpheme words such as *brand* with two-morpheme words such as *rained*. In both these sets of words the final consonant cluster is pronounced the same - /nd/. If children use their knowledge of morphology, they should be less likely to leave out the '*n*' in *rained* than in *brand*, and so, for example, spell *brand* as BRAD and *rained* as RAND. This is what Treiman and Cassar found when they tested kindergarteners, 1st and 2nd graders. In addition, children were more likely to spell *rained* as RAN than *brand* as BRAN; they seemed to have represented the first morpheme of *rained*, then forgotten the second morpheme. This type of spelling error could be interpreted as evidence of morphological segmentation.

Treiman's work shows that even though young children use morphology as a guide to spelling, they do not do so consistently until a few years later. The adoption of a morphologically based strategy for the spelling of verb inflections by children aged around nine has been reported in studies on Brazilian, American, French and English children (Beers & Beers, 1992; Nunes Carraher, 1985; Nunes et al. 1997a; Totereau, Thevenin, & Fayol, 1997).

The question of what underpins this shift in spelling, from phonological to morphological, is not clear. There are two possibilities. The first one, which has received the most attention in the literature, is that children's awareness of morphological rules in spoken language impacts upon spelling. The second one, which has been proposed by Egan & Tainturier (in prep) suggests that although morphological awareness is important, this shift is primarily underpinned by children's awareness of orthographic conventions, which have been gained through an increase in sight reading.

(i) Morphological rules and spelling

Rubin (1988) assessed kindergartners and 1st graders on the Berry-Talbott Language Test (Berry & Talbott, 1966), which is a measure of morpheme production in spoken language. It is similar to the Berko (1958) test. An example of an item on this test is, '*This is a nad who knows how to trom. He is tromming. He did the same thing yesterday. Yesterday he _______ (trommed)*'. On the basis of the children's performance on this task, she divided the two age groups into those with high and low morphological awareness. The children were also assessed on explicit morphological awareness, which involved detecting a base form in either one-morpheme or inflected words (e.g., '*Do you think there is a smaller word in kissed that means something like kissed?*'), and on phoneme segmentation. The children were then given a spelling test of 28 words, 18 of which had morphological endings. The words ended in non-nasal consonant clusters (e.g., *nest, messed, dust, fussed*) and nasal consonant clusters (e.g., *band, canned, wind).*

The basic finding was that children with poorer implicit morphological awareness, as measured by the Berry-Talbott test (Berry, 1977), were more likely to misrepresent inflectional endings, and that younger children were more likely than the older children to misrepresent inflected endings.

How does morphological awareness inform spelling later on? And is the transition to correct use of inflectional endings piecemeal or sequential?

This question was addressed by Nunes et al. (1997a, 1997b). They assessed children aged between six and nine on their ability to spell 10 regular past tense verbs (e.g., *covered, laughed*), 10 irregular past tense verbs (e.g., *lost, sent*) and 10 non-verbs (e.g., *gold, belt*). Half of the words in each category ended in a /d/ sound and half ended in a /t/ sound (see Table 3.2).

The aim of the study was to look at whether stages existed in children's acquisition of the *–ed* ending. In addition, it investigated how children's ability to use the *–ed* ending related to their level of grammatical awareness. The tasks of grammatical awareness were: (a) a word analogy task, in which children were given a word pair like *anger-angry* and then given a word and asked to make an analogy along the lines of the one they had just heard, for example *strong-_____? (strength)*; (b) a sentence analogy task, which was similar to word analogy except only inflectional verbs were used and items were presented in a sentence format, for example, '*Tom helps Mary. Tom helped Mary. Tom sees Mary.*

Tom _________' *(saw Mary)* (see Appendix A for full test). Finally, an adaptation of Berko's (1958) productive morphology task was used.

Table 3.2. The verbs and nonverbs used in Nunes, Bryant, & Bindman's study (1997a)

	/d/ sound ending	/t/ sound ending
Regular verbs	called	dressed
	covered	kissed
	filled	laughed
	killed	learned
	opened	stopped
Irregular verbs	found	felt
	heard	left
	held	lost
	sold	sent
	told	slept
Non-verbs	bird	belt
	cold	except
	field	next
	gold	paint
	ground	soft

The children's spellings revealed a progression from an exclusive, phonetic strategy to a grammatical strategy is sequential, occurring through five stages (Table 3.3). Initially, children over-used the *-ed* ending by placing it on the end of both irregular verbs (e.g. KEPED) and non-verbs (e.g. SOFED). Gradually, they become more discriminatory and stopped making the generalisation to non-verbs but continued to make them for irregular verbs. Nunes et al. (1997a) argued that this step signified that children were able to distinguish between verbs and non-verbs. Finally, children used the past tense endings correctly.

Table 3.3. The Five Developmental Stages of Morphological Spelling from Nunes, Bryant and Bindman (1997a).

Stage	Characteristics of the children's spelling	Typical spelling	Approx age
1	Unsystematic spelling of word endings		6y
2	Frequent phonetic transcriptions of endings: failure to produce *–ed* endings	kist, slept, soft	7y
3	Some *-ed* endings, but generalisations to irregular verbs and nonverbs (i.e. failure to confine this sequence to past verbs)	kissed, sleped, sofed	7y 6m-8y
4	*-ed* endings confined to past verbs, with generalisations to irregular verbs	kissed, sleped, soft	8y-9y6m
5	*-ed* endings confined to regular past verbs: no generalisations	kissed, slept, soft	9y6m-11y

In order to exclude the possibility that the children's spelling of the verbs was influenced by familiarity with the verbs, a further study using pseudo-verbs was developed (Nunes, Bryant, & Bindman, 1997b). The same sequences emerged, although this study has been criticised by Egan & Tainturier (in preparation).

How did the children's spelling link to their grammatical awareness? Their performances on the word analogy and sentence analogy, but not the productive morphology task, were predictive of the children's ability to use morphological principles in spelling. Nunes et al. (1997a) argued that the former two tasks required explicit recognition of the grammatical status of a word, whereas the productive morphology task demanded more implicit knowledge. Consequently, they suggested children's grammatical awareness must reach an explicit level for them to adopt a morphologically based spelling strategy.

In the studies outlined above, children show some ability to relate morphological knowledge to spelling at quite an early age. These findings have been mirrored, to some degree, by research on French children's spelling development.

Using morphological knowledge in spelling may be more important in French, because many verb inflections are not pronounced in speech, so *ils chantent* (they sing) and *il chant* (he sings) sound the same. For nouns, plurality is obvious in speech only when the noun is preceded by the determiners *le/la* or *les*. As the determiner is used most of the time before a noun, this aids children's spellings to a great degree. In the main, however, there are few phonetic prompts to help French children.

Toterreau et al. (1997) carried out a study looking at children's acquisition of number morphology in writing. They adapted Berko's (1958) task to written comprehension and production tasks using words taken from first grade books. In the comprehension task, children were presented with pictures of one or several objects, persons, or actions and they had to match the picture to a written representation. For the nouns, the words were either isolated (e.g. *chiens* - *dogs*) or combined with an article (e.g., *des poissons – some fish*), and for the verbs they were either isolated (e.g., *volent – fly*, third person plural) or presented with a pronoun (e.g., *ils marchent – they walk*). In a second experiment, the same principle was used except this time there was only one picture and two written representations, such as a picture of some apples and the words *la pomme* [the apple] and *les pommes* [the apples].

In the production task the children were again given pictures with objects, people, or actions and had to write down the appropriate word which completed the sentence relating to the picture. For example, they were shown a picture of a house with smoking chimneys and given the phrase *Les cheminées* _______ (*fument*) [the chimneys smoke].

Totereau et al. tracked the children over a six month period (twice for 1st graders, five times for 2nd graders and, because of their near ceiling performance, once for third graders) and their data revealed three stages in the acquisition of written morphology for nominal and verbal number.

> Stage 1. Comprehension of plural markers for nouns. Comprehension of plural markers for verbs only occurs when two written representations are available, for instance, they can more accurately recognise the correct marker for verbs when given a choice of the singular and plural. Comprehension of plural markers for both nouns and verbs is better when these words are proceeded by complementary markers (i.e., *le/la/les* for nouns and *il/elle/ils/elles* for verbs).
>
> Stage 2. Comprehension of plural markers for verbs without the need for two written representations. Comprehension of words without the need for complementary markers.
>
> Stage 3. Production of plural markers for nouns, followed some time later with the correct production of plural markers for verbs. This is consolidated by 3rd grade (age 9-10).
>
> This research shows that the automisation of written morphology for number occurs sequentially, and that its comprehension (i.e., reading) precedes its production (i.e., spelling).

In a further study, Totereau, Barrouillet, & Fayol (1998) found 6-10 year-old French children make overgeneralizations of noun and verb plural endings that are strikingly similar to the sort English children make with the *–ed* ending. Children were asked to write the correct ending on two word phrases containing nouns or verbs (e.g., *ils rêves-/les rêvent* - they dream/the dreams). Four stages emerged: (1) zero marking for nouns or verbs; (2) use of the *–s* ending for plural nouns and over-generalisation of this to plural verbs (e.g., *ils rêves* rather than *ils rêvent*); (3) use of the *–nt* ending for plural verbs, and the overgeneralisation of this to plural nouns (e.g., *les timbrent* rather than *les timbres;* the stamps); and (4) correct use of the *–s* ending for nouns and the *–nt* ending for verbs.

Aside from helping French children with inflectional endings, Sénéchal (2000) showed how French speaking children's awareness of morphology in spoken language related to their ability to apply silent consonants onto the ends of words with morphological relations that revealed silent consonant endings. For instance, although the final /k/ in *blanc,* is silent, knowledge of its feminine form *blanche* could help children to correctly place the final '*c*'. Similarly, although the final /t/ in *début* is silent, the /t/ is evident in morphological relations such as *débutant(e).* Regression analysis showed that morphological awareness as assessed by a French version of Nunes et al.'s (1997a) word analogy task, was predictive of correct placement of silent endings, even after phonological skills and print exposure had been entered in the regression.

The studies cited above all imply that morphological awareness precedes or causes spelling of inflected endings. However, it is also likely that a reciprocal relationship exists between morphological awareness and reading, in the same way that phoneme awareness develops as a consequence of learning to spell. Derwing, Smith, and Wiebe (1995) suggest that orthographic knowledge gained from learning to spell may affect the development of morphological awareness in spoken language (in the same way learning to read aids phoneme awareness in spoken language).

(ii) Rote based learning and inflectional spelling

Egan and Tainturier (in preparation) propose that while morphological awareness has an effect on children's spelling of the past tense *–ed* ending, the notion that young children explicitly apply morphological rules to spelling is tenuous. They assessed 117 children aged between 6 and 14 years of age on their ability to spell /t/ and /d/ sound endings non-words. The same non-words were presented over two occasions in a noun and verb context (e.g., /gukt/. Noun: The /gukt/ is red. Verb: He /gukt/ the sweets.). The prediction was that if children use rules in spelling the ending of real past tense verbs, they should use the *–ed* ending on non-words when they are in a verb context (e.g., gucked), and a phonetic ending (i.e., /t/ or /d/) on the same non-words in a noun context (e.g., guct).

Even though children aged 9 years were at ceiling when using the *–ed* ending on real regular past tense verbs, they did not spell non-words according to their syntactic class until the age of 11 years. Furthermore, although morphological awareness emerged as a predictive factor in spelling of the *–ed* ending, it was not as important as children's orthographic knowledge, as assessed by their reading and spelling of irregular words like *wrist*.

Further support for a rote based view comes from studies showing how word frequency affects children's use of inflectional endings. In the Totereau et al. study (1998) mentioned earlier, it was found that two factors affected the occurrence of generalisations of plural noun endings to plural verbs and vice versa. Firstly, children were more likely to make errors on noun-verb homophones (e.g., *il rêve/le rêve*; he dreams, the dream), than on nouns or verbs with no homophone (e.g., *le nuage; il donne*, the cloud; he gives). If rules provide the primary impetus for children's over-generalisations, then no difference between homophones and non-homophones would be expected. A second finding was that the probability of a child adding the plural verb *–nt* ending to a plural noun was far greater when the verb form of the word had a higher frequency than the noun form.

A similar finding has been reported in a study on Dutch children (Frisson & Sandra, 2002). At the age of 8 years, children in the Netherlands are taught that for the first person singular present, the stem of the verb is used, and for the third person singular, *-t* is added to the stem (just as *–s* is added in the English version of this verb conjugation). In most cases, there is a strong phonemic correspondence between sound and spelling in Dutch, so these verb forms are mostly spelled correctly. However, in cases where the verb forms are homophonic (e.g., *rijd* [drive] and *rijdt* [drives] are both pronounced /rɛit/), spellers aged between 12 and 14 years made errors such as *ik rijdt* [I drives]. It emerged that the incorrect form produced by the spellers was always the one with the higher frequency. For instance, *rijdt* is almost 3 times more frequent than *rijd*, so spellers were more likely to write *ik rijdt* [I drives] than *hij rijd* [he drive]. Furthermore, a previous study by these authors showed even competent adult spellers made inflectional errors of this nature (Sandra, Frisson, & Daems, 1999). The data from these two studies lead to the conclusion that, when faced with two homophonic alternatives, the frequency of rote learned words over-rides even the most basic and earliest learned morphological spelling rules.

Further criticism of the idea that morphological rules are used in spelling comes from Kemp & Bryant (2003). They assessed children and adults on their use of the *–s* plural inflection, and found that the morphology based rule governing this inflection (i.e., /z/ and /s/ are represented as *–s* in regular plurals) was not used by children, and was only used to a limited extent by adults, in their spelling of non-words.

Summary of data on morphology and literacy development

Morphology's role in reading development is important for comprehension and, to a lesser degree, decoding. In spelling, children's use of morphology progresses in a stage-like manner. Research suggests that its usage in written language appears to be affected by two main factors: the child's levels of explicit morphological awareness in spoken language, and their lexical memory for written words.

3.7 Morphological processing in dyslexia

Many dyslexic children never attain high levels of literacy. Given the importance of morphology in literacy acquisition, it is possible that, in addition to their phonological deficits, dyslexic children have impairments in morphology. Impairments in morphology could be present in spoken language, and these would have an effect on written language. Conversely, morphological impairments could be limited to written language processing.

Morphological processing in dyslexic children's spoken language

As was mentioned earlier, morphology is closely linked to syntax. Therefore, specific problems with morphology in spoken language could be due to more generalised difficulties with syntax.

(i) Syntax

A number of studies have shown that dyslexic children are inferior to normal readers on tests of syntactic ability (Bohannon, Warren-Leubecker, & Heper, 1984; Bowey, 1986; Brittain, 1970; Byrne, 1981; Flood & Menyuk, 1983; Goldman, 1976; Guthrie, 1973; Scarborough, 1990; Siegel & Ryan, 1984; Stein, Cairns, & Zurif, 1984; Tunmer, Nesdale, & Wright, 1987; Vogel, 1974; Wiig, Semel, & Crouse, 1973; Willows & Ryan, 1986). The question is, why?

Their weak syntactic skills may be due to language delays. In Scarborough's (1990) seminal study, two and three year-old children who went on to become dyslexic had greater difficulty with speech production and used more limited syntax in their conversations with their mothers. At the very least this suggests that, at some point, dyslexic's syntactic development may well be delayed relative to their peers. Whilst this delay may not affect their spoken language later on, it could be an impediment on explicit tasks of syntactic awareness.

It has been suggested that dyslexic children's syntactic difficulties are in fact due to factors other than deficits in the part of the language system that processes syntax. Some, notably Shankweiler and colleagues, have suggested dyslexics' syntactic difficulties can be accounted for by their poor short-term memory skills caused by weak phonological encoding processes (Fowler, 1988; Shankweiler & Crain, 1986; Shankweiler, Crain, Brady, & Macaruso, 1992; Shankweiler, Smith, & Mann, 1984; Smith, Macaruso, Shankweiler, & Crain, 1989; Shankweiler et al., 1995).

Shankweiler et al. (1995) compared dyslexic children with normal readers and other learning disabled groups (ADHD and calculation deficits) on measures of syntax. Tape-recorded versions of syntactically ambiguous (whereby the sentence could have two meanings) and unambiguous sentences were spoken and the child had to decide if the sentence matched a picture on screen. Their decision time and errors were dependent variables. In addition, tests of reading accuracy and comprehension were administered.

Shankweiler et al. (1995) found poor readers performed similarly to other learning disabled groups on the syntax task. After IQ and listening comprehension were controlled, the learning disabled groups did not perform more poorly than the normal readers. They concluded from this that dyslexic children do not have syntactic deficits per se, and proposed that the syntactic problems reported in other studies were due to task demands, which stressed dyslexics' weaker short-term memories. A related view suggests that syntactic deficiencies might be due to poor attentional processes (Deutsch & Bentin, 1996).

(ii) Morphological awareness

Morphological awareness studies comparing dyslexic children with control groups have focused on derivational or inflectional processing, and, to a lesser extent, compounding.

(i) Derivational processing

Fowler and Liberman (1995) tested good and poor readers aged between 7.5-8.5 years and 8.5-9.5 years. They assessed children's morphological awareness by asking them to generate a derived target from a base form (e.g., *Four. The big racehorse came in* _______), and generate a base target from a derived form (e.g. *Fourth. When he counted the puppies, there were* _______). Half the transformations involved a phonological change (e.g., *five-fifth*) and half were phonologically simple (e.g., *four-fourth*). Six suffixes were used (-ous, -y, -th, -able/-ible, -ation, -tion/sion) in both conditions.

Overall, children found generating derived forms from base forms more difficult than extracting base forms from derived forms. There were relationships between the children's performance on the morphology tasks and their reading, vocabulary, and non-word reading and spelling. In each age group, the better readers outperformed poor readers on the phonologically complex condition but not the phonologically neutral condition, which would place poor readers' apparent difficulties with derivational morphology at the phonological level.

Shankweiler et al. (1995) conducted a similar study with the children they used in their study on syntax reported earlier. They measured these groups on phonological awareness (phoneme deletion) and verbal short-term memory (for sentence repetition, random word sequences, and digit sequences). They used the same measures of morphological awareness as Fowler and Liberman (1995). All children made more errors in the phonological change condition. Although the dyslexic children were worse than the normal and learning disabled control groups in both the phonological change and phonological no change conditions (which differs slightly from Fowler and Liberman's finding of no difference in the phonological no change condition), they were more affected by the phonological change condition than the other readers. Their performance on the morphology task related to their performance on short-term memory and phonological discrimination measures, which suggests that the two skills are tapping the same underlying process. Like Fowler and Liberman (1995), they argued that this result could be accounted for within the phonological deficit hypothesis of dyslexia.

A similar study by Leong and Parkinson (1995) looked at naming latencies, as well as correctness of response. They compared above and below average readers from grades 4, 5, and 6 on a naming task similar to the one used by Fowler and Liberman (1995) and

Shankweiler et al (1995). A sentence frame was shown on screen and the children's ability to produce a derived form from a base was timed. There were four conditions: no change (e.g., *final-finally*), orthographic change condition in which consonant doubling occurs (e.g., *sun-sunny*), phonological change condition (e.g., *heal-health*) and both phonological and orthographic change condition (e.g., *explain-explanation*). The poorer readers had greater difficulties with these tasks, particularly the phonological change and orthographic and phonological change conditions. The 6^{th} grade poor readers took longer to generate words in these conditions compared to good 4^{th} and 6^{th} grade readers, but were quicker than the 4^{th} graders on the no change and orthographic change conditions. Again, this places their morphological deficits at the phonological level.

A study on Israeli children with dyslexia found they were poorer than chronological aged controls in derivational processing but the same as a vocabulary matched group (Ben-Dror, Bentin, & Frost, 1995).

The findings of these studies all suggest that dyslexics are impaired at processing derivational morphology in spoken language compared to chronological age matched children. Although in two of the studies, the dyslexics were worse than same age peers on phonologically neutral sets, they were not worse than reading level matches on these sets. Consequently, problems with derivations that are phonologically neutral could be due to poor reading experience rather than discrete problems with derivational morphology. The finding that phonologically complex sets were far more challenging for the dyslexics is suggestive of problems in the phonological lexicons.

One problem with this conclusion is that none of the researchers in the studies outlined above have clearly explained why producing phonologically complex changes, such as *five-fifth*, are more difficult than phonologically neutral changes like *four-fourth*. It could be that children with good phonological skills are simply better at remembering related words that deviate phonologically.

(ii) Inflectional processing

Studies comparing dyslexic children to normal readers on inflectional morphology typically use Berko's (1958) task (e.g., *Here is a wug. There is another one. There are two of them. There are two* _______?').

It has generally been found that dyslexic children are impaired on this task relative to control groups of the same age (Bryant, Nunes, & Bindman, 1998; Doehring, Trites, Paterl, & Fiedorowicz, 1981; Joanisse, Manis, Keating, & Seidneberg, 2000; Vogel, 1983; Wiig, Semel, & Crouse, 1973). Studies show that progression through the 14 morphological stages is similar, but delayed, for dyslexic children (Morehead & Ingram, 1973; Vogel, 1983). Only one study suggests dyslexic children are not impaired relative to chronological age controls (Smith-Lock, 1991) but this finding can perhaps be attributed to the fact that her task was less explicit than the Berko-type assessment used in other studies, and probably not sensitive enough to tease out differences between groups.

When compared to those with similar reading ages there appear to be no differences (Bryant et al., 1998; Elbro, 1989; Elbro & Arnback, 1996; Joanisse et al., 2000). However, Joanisse et al. (2000) found that when their dyslexic group was split into three subgroups (delayed, phonological and language impaired), the language impaired children, whose vocabulary scores were poor and who scored low on a speech perception task, performed less well than the reading-age matches.

An on-going Finnish study comparing 'at risk' and control infants has found that 'at risk' children perform more poorly than controls at age 3.5 on measures of inflectional morphology (Lyyinen, 1997). However, as variations between morphemes in Finnish are confined to a single phoneme at the ending, Van der Leij, Lyytinen & Zwarts (2001) suggest that this problem is consistent with the children's poorer scores on phonological tasks.

In conclusion, while dyslexic children may appear to have morphological impairments in spoken language compared to chronological aged controls, many studies have concluded that this weakness can be accounted for to some extent by their well documented phonological deficits. However, this view stems mostly from findings on phonological change derivational tasks. Far fewer studies have been carried out on inflectional processing using comparisons with both spelling and reading age matched controls, and on simultaneous tasks of phonological processing, so dyslexic children's relative weaknesses in this domain remain unclear.

Morphological processing in written language

The research on how dyslexic children process morphologically complex words in written language is fragmented. Some studies have focused on inflections, others on derivations. In some studies a case study design has been employed, whereas others have compared groups. The writing samples have been taken from free writing samples in some cases, and single word tests in others.

(i) Reading

Clinical reports have described cases of dyslexic children who have a tendency to misrepresent morphemes, particularly inflectional endings, in reading. Temple (1984a; 1997) found JE, a 17 year-old phonological dyslexic, made a substantial number of morphological errors in reading aloud; they constituted 55% of her errors. Temple's (1984b, 1985b, 1990c) case AH also made a substantial number of morphological errors, such as omissions and substitutions, on derived and inflected words in reading (54%). Similarly, Henderson and Shores (1982) report the case of two 9-year-old boys who omitted or substituted verb endings in reading; these errors constituted 40% of their total errors in oral reading. A group study by Elbro (1989) found that severely dyslexic adolescents made a significant number of errors on inflected endings in reading aloud. They were also behind reading level controls in their ability to reverse elements of compound words and produce whole words containing target morphemes.

In comparison to both chronological and reading age matched children, dyslexic children appear to process morphologically complex words in a qualitatively different way.

Leong and Parkinson (1995) reasoned that if poor readers are less sensitive to the morphological aspects of words, they should be less affected by morphological primes. Using the paradigm of repetition priming, they compared below and above average readers in grades 6 and 7 on lexical decision making. There were four types of prime: control (xxxx priming *lone*), same (*lone* priming *lone*), morphologically related (*lonely* priming *lone*) and morphologically unrelated (*loans* priming *lone*). Lexical decision times were faster for both groups in the morphologically related condition, but the facilitation effects were greater for the above average readers. Unfortunately, there were no reading level matches with which to compare the poor readers, so it cannot be confirmed whether or not the dyslexics' lower sensitivity to morphological primes were due to lower numbers of lexical items or specific difficulties with the way in which morphologically related words are stored in the orthographic lexicon.

The examples above relate to inflectional and derivational morphology, which are possibly dealt with through a process of parsing. Compound words, which comprise two stem morphemes (e.g., *doghouse*), contain a great deal of semantic information. In some cases, a compound word's meaning is transparent; it is clear that *sunburn* means being burnt from the sun, and *postman*, is a man who delivers post. Other words that appear to be compounds are in fact not, so their meaning is not the result of the sum of their parts (e.g., *window*).

Elbro and Arnback (1996) suggested that if dyslexic children do not make use of morphological information, there should be no difference in their ability to read transparent and opaque words. They compared 26 dyslexic adolescents (mean age 15.3 years) with 26 younger normal readers (mean age 9.4 years). A set of matched transparent and opaque words was presented to the children and it was found that the dyslexic teenagers read the transparent words more quickly and accurately than the opaque words, whereas for the normal readers there was no difference. This suggests that dyslexics rely *more heavily* on morphological structure, particularly when the semantic link is transparent, than younger reading level controls.

Elbro and Arnback (1996) thought that dyslexics may be more facilitated in reading if words were presented as morphemic units. They presented the participants from their first study with sentences in word-by-word formats. There were five conditions: one letter at a time, one syllable at a time, one morpheme at a time, one word at a time or the whole sentence was made visible. The participants found the letter-by-letter condition too difficult, so these results were excluded from analyses. They found the dyslexics read faster and more accurately in the morpheme-by-morpheme condition than in the syllable-by-syllable condition. In fact, they were as good in the morpheme condition as in the word-by-word condition. Conversely, the normal readers found the syllable-by-syllable condition easier.

However, the link between morphological knowledge and reading skills in dyslexic adolescents is not clear-cut. In a longitudinal study, Tornéus (1987) found the link was particularly strong for children with an above average IQ.

(ii) Spelling

Turning first to derivational spelling, it appears that older dyslexics, who have mastered grapheme-phoneme rules, fail to use morphological knowledge in spelling these types of words. They show a tendency to omit these morphemes, so they produce sentences like, "It is protecting familyhood of which I am a strong belief" (Shaughnessy, 1977).

Carlisle (1987) compared dyslexic ninth graders with normal reading fourth graders and found the dyslexics were less likely to note the relationship between stems and derivations. For instance, whilst they were as good as younger normal spellers in their ability to spell words like *magic*, they were less able to use the link between *magic* and *magician*, so produced errors such as MAGISHIAN, MAGISTION and MAGISHION. Similarly, Hanson, Shankweiler, and Fischer (1983) found dyslexic adolescents could spell words like *plastic* or *splinter* as well as chronological age matched normal readers, but were more likely to make errors on morphologically complex words like *condemnation* and on words spelled through knowledge of orthographic conventions, like *heroes* and *galleries*. In a further study of college students, Fischer, Shankweiler, and Liberman (1985) found (non-dyslexic) poor spellers often failed to see the links between morphologically related words in their writing, so would produced HELTH for *health*. They were also less able than good spellers to indicate the boundary between base morphemes and suffixes.

Similar findings have been reported by Templeton and Scarborough-Franks (1995) and Worthy and Viise (1996).

For inflected words, Smith-Lock (1991) assessed 18 normal and 11 poor readers who were in second grade on their ability to spell inflected words. All the children were of average or higher intelligence. The normal readers were those who scored above the 50^{th} percentile on the Metropolitan Achievement Test and the poor readers were those who scored below the 23^{rd} percentile. Ten sentences containing complex syntactic structures were generated, and the procedure involved presenting the children with a toy, people or animals (a man, a lady, and a cat) and objects (french fries, balls, and beds). A puppet (Ernie) was presented and the child was asked to write a note to the puppet asking it who it thought performed a particular action. In all, there were 20 opportunities for children to make omissions and substitutions to inflections, and 10 opportunities for addition. The poor readers made many more morphological omissions (but not substitutions or additions) than the normal readers. These errors could not be accounted for as final phoneme omissions, as few of these were made on one-morpheme words. Smith-Lock concluded that poor readers have a weak explicit awareness of the morphological structure of words. Unfortunately, she did not include a reading/spelling level match, so we cannot be sure if their poorer spelling of inflections was simply due to the fact that they were poorer spellers than the CA group.

Johnson & Grant (1989) elicited stories from normal and reading impaired children (they referred to them as Learning Disabled) in Grades 1-3 on the Picture Story Language Test (Myklebust, 1965). They found many children in their Learning Disabled group omitted inflectional endings, but the significance of this was not tested.

Using a reading level match design, Bryant et al. (1998) found no difference between controls and poor readers (who were recruited on the basis of normal IQ and a 2 year chronological age/reading age discrepancy) on their ability to spell inflected verbs. Similarly, Bruck (1993) found dyslexic college students whose global spelling skills were worse than those of 6^{th} graders, were nevertheless equivalent to these children on their ability to correctly represent morphological information.

Summary of data on dyslexic children

The data show that in spoken language, dyslexic children are poorer than those of the same age on tasks of both inflectional and derivational awareness. They are particularly more impaired on derivational tasks that involve a phonological shift between the base and derived forms. They do not appear to be poorer than younger children matched on reading ability, but comparisons with those matched on spelling have not been carried out, so their performance relative to this group remains unclear. Overall, the data would suggest that dyslexic children's morphological awareness in spoken language is commensurate with their literacy skills. The implication of these data is that morphological skills in spoken language may be affected by literacy development. Presumably, exposure to the written form of morphologically complex forms enhances children's explicit awareness of language.

With regards to reading and spelling, studies show dyslexic children are always poorer than chronological age matched controls in reading and spelling morphologically complex words, but as they are poorer than this group on spelling most types of words, not a great deal can be concluded from these data.

Only two studies have explicitly tested whether dyslexic children have morphological deficits compared to younger children. Carlisle (1987) found the dyslexic ninth-graders were behind the reading level controls when asked to spell morphologically complex words, and she found this impairment could not be attributed to poor grapheme-phoneme awareness. Conversely, Bryant et al. (1998) found their poor readers were no worse than younger reading age matched controls on allocating the *–ed* ending to regular past tense verbs. However, in Bryant et al.'s study, the poor readers were not necessarily dyslexic; they were a retrospectively gained group whose reading was two years below their chronological age rather than a clinically diagnosed group.

A systematic study comparing dyslexic children with both chronologically aged, and reading and spelling aged matched normally achieving children on their reading and spelling of morphologically complex words is needed. The children's performances should be compared on a range of linguistic tasks in order to tease apart the possible origins of the dyslexic children's morphological difficulties in spelling.

CHAPTER 4

INTRODUCTION TO THE EXPERIMENTAL SECTION

The literature reviewed in Chapter 3 shows that relatively little research has been carried out into the topic of morphological processing in dyslexia. Previous studies have focused on different aspects of morphology, and have used differing experimental designs. Consequently, the evidence gathered to date does not provide a clear view of how dyslexic children process inflectional morphology.

There is a pressing need for a solid study to be carried out investigating how dyslexic children process inflectional morphology in written and spoken language. This thesis aims to clarify the following outstanding issues:

1. *Do groups of dyslexic children make more errors in their reading and spelling of inflected forms in relation to reading and spelling age matched controls?*

   Previous studies that report differences relative to reading age-matched controls (e.g., Carlisle, 1987) may not provide an accurate picture, because the reading age matched controls could be better spellers. The few studies that have compared dyslexic children to those matched on spelling ability show that dyslexic children demonstrate more primitive phonological spelling than children who are normally developing spellers (Bruck, 1993; Bruck & Treiman, 1990; Kibel & Miles, 1994), but equal or better knowledge of orthographic patterns (Lennox & Siegal, 1998).

2. *What type of errors do dyslexic children make on inflected forms in reading and spelling?*

   Previous studies have shown that the predominant type of error dyslexic children make in reading and spelling of inflected verbs are omissions (Elbro, 1989; Henderson & Shores, 1982; Johnson & Grant, 1989; Smith-Lock, 1991; Temple, 1984b, 1985b, 1990c). However, the extent to which these errors occur in relation to errors made on one-morpheme words has not been addressed.

3. *To what extent are dyslexic children's difficulties with morphology in written language due to poor phonological skills, morphological skills, or orthographic knowledge?*

   In previous research, not all of these factors have been simultaneously assessed in the same study.

4. *Are difficulties with morphological processing in written language a feature of dyslexia per se, or are these problems constrained to a sub-group of dyslexic children?*

   In previous studies, case studies have described children who make significant numbers of errors on inflected forms (Henderson & Shores, 1982; Temple, 1984b; 1985b; 1990c), and group studies using reading age matched controls have shown group differences (Elbro, 1989; Johnson & Grant, 1989). However, the extent to which a sub-group of dyslexic children with specific problems may contribute to group differences has not been assessed.

PILOT STUDY

A comparison between dyslexic children, spelling and reading age matched children, and chronological age matched good and poor readers in their spelling of regularly inflected verbs, and their awareness of morphology and grammar in spoken language

Introduction

The first purpose of this study was to establish whether or not dyslexic children had difficulties in processing inflectional morphology in written and spoken language before investing time carrying out a large scale study.

The second purpose of the study was to investigate the types of tests that could be used in a larger study, and assess appropriate age groups for further testing.

A final aim of this study was to see if differences existed between children who had a diagnosis of dyslexia, and those whose poor reading and spelling abilities were not unexpected in the light of their non-verbal cognitive abilities. If both the dyslexic and poor reader groups performed similarly on measures of inflectional morphology, this would mean that the groups used in further research could comprise a more loosely defined set of poor readers. However, if the dyslexic children performed differently, this would indicate that future studies should include only strictly defined groups of dyslexic children.

Method

Participants

Twelve dyslexic children (DR) were compared to 12 poor readers (PR), 12 younger reading-age matched children (SA-RA), and 12 chronologically-age matched readers (CA). There was an equal proportion of girls and boys in each group. Both the DR and PR groups were more than 2 years below their chronological age in spelling (Schonell, 1956) and reading (Neale, 1997). The DR group had no physical, neurological, social, or behavioural problems that could account for their difficulties with literacy, and had all be categorised as dyslexic by an Educational Psychologist. The PR group was attending a school run 'booster' literacy programme for children identified by school special needs co-ordinators as non-dyslexic poor readers. The standardised tests used to match the groups on reading, spelling, and IQ were the Neale Analysis of Reading IIR (Neale, 1997), the Schonell spelling test (Schonell, 1956), and the NFER non-verbal test (NFER, 1993). The characteristics of the children are shown in Table 4.P.1.

The DR group was matched to the SA-RA controls on reading accuracy and spelling, and to the CA group on non-verbal IQ. They were matched to the PR group on reading accuracy and socio-economic status (as this may have affected spoken language experience), but the PRs were significantly better spellers ($p < 0.01$).

Processing of inflectional morphology and grammar in spoken language

The children were individually administered two tests of grammatical awareness. The Test for Reception of Grammar (TROG) (Bishop, 1983) was included to determine the children's general grammatical knowledge. Children's inflectional morphological awareness was assessed by the "sentence analogy" task, devised by Nunes et al. (1997a). In this task, the child is presented with 8 pairs of spoken sentences (e.g., *Tom* *helps Mary. Tom helped Mary*), then provided with another sentence (e.g., *Tom sees Mary*), and asked to produce a new sentence by changing it in the same way that the second sentence had been changed from the first in the first set (e.g., *Tom saw Mary*) (Appendix A). The children's scores on the two spoken language tasks are displayed in Table 4.P.2.

Table 4.P.1. Mean assessment scores for the dyslexic children, poor readers, chronological age-matched-group and the spelling and reading-age-matched group.

	DR (N=12)	PR (N=12)	CA (N=12)	SA-RA (N=12)
Mean Age	11.3 (0.44)	11.1 (0.02)	11.4 (0.47)	8.3 (0.73)
SES[a]	3.4 (1.0)	3.7 (0.78)	2.5 (0.52)	2.5 (0.86)
Reading Accuracy Age[b]	8.1 (0.79)	8.2 (0.7)	11.9* (0.58)	8.1 (0.78)
Reading Rate Age[b]	9.2 (1.4)	9.2 (1.0)	11.7* (0.66)	8.5 (0.9)
Reading Comprehension Age[b]	8.4 (0.65)	8.4 (1.14)	11.9* (0.39)	8.72 (1.15)
Spelling Age[c]	7.8** (0.96)	8.7 (0.64)	11.7* (0.76)	8.1 (0.81)
Non-verbal IQ[d]	103.3** (7.7)	81.8* (9.18)	106.3 (0.93)	103.2 (3.6)

Note. Asterisks indicate differences between each group compared to the SA-RA group, $p < 0.05$. Two asterisks indicate differences between the DRs and PRs. Standard deviations are indicated in parentheses.

[a] Five scales of SES were used, with 1 being professional and 5 being unskilled/unemployed.

[b] Neale Analysis of Reading IIR.

[c] Schonell spelling test

[d] NFER Non-Verbal Reasoning.

Table 4.P.2. Means and standard deviations for the four groups' performances on the spoken tasks of grammar and morphology

	DR	PR	CA	SA-RA
TROG raw	17.58	17.16	19.41	17.33
(max = 20)	(1.16)	(1.19)	(0.9)	(1.37)
Sentence analogy	6.6	6.8	8.0	5.7
(max = 8)	(1.2)	(1.3)	(0.0)	(1.5)

Note: Standard deviations are in parentheses.

On the raw scores of the TROG, there was a significant difference between groups, $F\ (3,44) = 9.52$, $p < 0.0005$. Post-hoc LSDs (significant to $p < 0.05$) found no difference between the DR, PR, and SA-RA groups, all of whom were significantly poorer than the CA group. For the sentence analogy task, the CA group outperformed each of the other three groups $F\ (3,44) = 8.02$, $p < 0.001$, all of whom performed similarly to each other.

Spelling of regularly inflected verbs

The children were given 30 words to spell: 10 regular past tense verbs (RPTs), 10 irregular past tense verbs (IPVs), and 10 one-morpheme words (OMs). Half of each set had a /d/ sound ending and half had a /t/ sound ending. The words were taken from Nunes et al. (1997a) (see page 86), and were matched listwise for frequency (Carroll, Davis, & Richman, 1971). The words were presented by the experimenter, firstly on their own, then in a sentence format, then on their own again (e.g., *Learned. I learned to ride a bike. Learned*). The control children were tested in class groups but the dyslexic children were assessed individually or in small groups because they were attending different schools. The scoring criteria used was as follows:

1. Correct ending used (e.g., kissed → kised)
2. *-ed* spelled *d* (e.g., kissed → kisd)
3. *-ed* spelled *t* (e.g., kissed → kist)
4. *t* spelled *d* (e.g., lost → losd)
5. *d* spelled *t* (e.g., held → helt)
6. final consonant omission (e.g., held → hel)
7. *-ed* addition (e.g., held → heled)
8. incorrect letter phonetically plausible (e.g., turned → turnede)
9. incorrect letter phonetically implausible (e.g., turned → turnth)

Results

The results of the number of endings spelled correctly by each group are shown in Table 4.P.3.

Table 4.P.3. Means and standard deviations for number of correct spellings on the three types of word endings

		DR	PR	CA	SA-RA
Regular verb endings (max = 10)	Mean	5.5	7.8	9.16	7.3
	S.D.	1.6	1.2	1.2	2.4
	Range	1-7	5-10	7-10	2-10
Irregular verb endings (max = 10)	Mean	8	9	9.6	8.6
	S.D.	2	0.95	0.8	1.6
	Range	4-10	7-10	8-10	5-10
One-morpheme word endings (max = 10)	Mean	8	9.4	9.3	8.9
	S.D.	1.8	0.5	0.8	0.9
	Range	5-10	9-10	8-10	8-10

The data were analysed with a split-plot ANOVA, with group (DR, PR, CA, SA-RA) as the between subjects factor and word type as the within subjects factor (RPT, IPV, OM). There was a significant effect of group, $F\ (3,44) = 6.23$, $p < 0.001$, and word type, $F\ (2,88) = 25.464$, $p < 0.001$, with all groups making more errors on RPTs, and a group by word interaction, $F\ (6,88) = 3.435$, $p < 0.01$. Post hoc LSDs showed the dyslexics made significantly more errors than all other groups on the spelling of RPTs ($p < 0.05$). There were no group differences between IPVs and OMs.

As the SA-RA and DR groups were matched on spelling ability, only the types of errors made by these groups were analysed. The most common error made by both groups on RPTs was to use a phonetic ending instead of *–ed*. The next most common error for the dyslexic group on RPTs was to use a *-d* on /t/ sound ending words. However, as this error was also evident on OMs, this was probably due to phonological bias, because /t/ and /d/ differ only on a voiced-voiceless contrast. The dyslexic group made more omissions on regular past tense verbs compared to the SA-RA group. However, they also omitted the final consonant from IPTs and OMs more frequently than the SA-RA group, which suggests that *–ed* omissions were due to a general tendency to omit the final sound of words.

Both groups generalised the *–ed* ending to IPTs more often than to OMs. This suggests that dyslexic children may use similar strategies to normally developing children in spelling, because they over-applied the *–ed* rule.

Discussion

The main finding from the pilot study is that the dyslexic children performed more poorly than the SA-RA group when it came to spelling the endings of regularly inflected verbs. However, they were similar on spoken measures of grammar. This suggests that dyslexic children may only have deficits in written, but not spoken, morphology.

There were ceiling effects on the grammatical tasks, which could mask some differences between the DR and SA-RA groups. The CA group was at ceiling on all measures in this study. Consequently, for the main study, larger groups of younger children should be assessed.

As the PR children were better spellers, as measured by a standardised spelling test, not much can be concluded from the DR-PR differences on spelling data. It is difficult to match PR and DR groups precisely, and in a large study it would be unfeasible to find such large groups who could be matched on reading and spelling measures. As the DR group were similar to the PR group on language measures, this would suggest that dyslexic children are not impaired relative to PR children on morphological tasks. Consequently, in the main experiments, only DR children will be recruited, and they will be compared to CA and SA-RA matched controls.

EXPERIMENT 1

A comparison between dyslexic children, spelling and reading age matched children, and chronological age matched children on their reading and spelling of inflectional morphemes

Method

Participants

The dyslexic group (DR) comprised 28 children in Year 5 (20 males, 8 females). The children were recruited by contacting all Primary schools in Chester, Ellesmere Port and East Flintshire, and asking school Special Need Co-ordinators (SENCos) if they had children in Year 5 (6^{th} year of formal schooling) who were at least two years behind in reading and spelling, despite otherwise normal physical and intellectual development. Thirty-five children were put forward and given consent forms; two children could not be included because their parents did not wish them to take part. The remaining 33 were assessed and selected for inclusion in the study if they fulfilled the following criteria: scores at or below the 25th percentile on both the WRAT 3 reading and spelling sub-tests (Wilkinson, 1993); absence of extenuating factors that could account for their difficulties with literacy (such as social problems, sensory, neurological or physical impairment, or conduct disorders); non-verbal ability, as measured by the Raven's Progressive Matrices (Raven, 1958), within the average and above average range (i.e., a standard score of 90 and above). Five children were excluded from the dyslexic sample because they did not fulfil these criteria. The final sample of 28 children came from 10 different schools.

The 28 children in the chronologically-age matched control group (CA) were drawn from a larger pool of 68 children in Year 5. They were matched pair-wise to the dyslexic children on chronological age (+/- 5months) and non-verbal ability (+/- 5 points on raw scores). A further criterion was that this group had reading and spelling scores on the WRAT-3 (Wilkinson, 1993) at or over the 30th percentile in both reading and spelling. The resulting group comprised 7 males and 21 females.

The 28 children in the reading and spelling age-matched group (SA-RA) were taken from a larger group of children (N = 98) in Years 2 and 3. They were matched pair-wise to the dyslexics on their raw reading and spelling scores on the WRAT-3 (Wilkinson, 1993). As the primary focus of the study was spelling, they were matched on this factor first (+/- 3 points), and then on reading (+/-5 points). All of the SA-RA children had standard reading and spelling scores above the 30th percentile and had non-verbal ability in the normal range (i.e., >90). The final SA-RA group comprised 10 males and 18 females.

It would have been ideal to match the groups on sex ratios, but this was not possible. The dyslexic group was reflective of the dyslexic population, in that it contained more boys than girls. The control groups were selected from larger groups, and after the key matching criteria had been applied, both control groups contained more girls. It was reasoned that any variance between the groups that could be due to sex differences (notably, superior language skills in the girls), was likely to be lower than variance that would arise from matching for sex first and then applying looser criteria on factors such as reading and spelling ability (in the case of SA-RA controls) and age and non-verbal ability (in the case of the CA group).

Both control groups were administered the Raven's Progressive Matrices (Raven, 1958) and the WRAT-3 (Wilkinson, 1993) spelling test in class groups. The dyslexic children, who attended different schools, were given these tests individually or in small groups. The WRAT-3 (Wilkinson, 1993) reading test was administered to all children individually. Though the WRAT-3 (Wilkinson, 1993) does not give reading and spelling ages, these were calculated by finding the age at which a raw score yielded a standardised score of 100. For instance, a raw score of 25 on reading corresponded with a standardised score of 101 for children aged between 7:03 and 7:05. The lower end of the range was always entered as the reading age, so the ages entered were not precise. However, it was thought useful to have some indication of the children's reading and spelling ages when discussing the children's results in terms of developmental patterns. The characteristics of the three groups are shown in Table 4.1.1.

Table 4.1.1. The mean age, IQ, and reading and spelling scores for the three groups of participants.

		DR N = 28	CA N = 28	SA-RA N = 28
Age	**Mean**	**9y9m**	**9y9m**	**7y6m**
	SD	4.42	3.83	7.28
	Range	9y3m-10y7m	9y3m-10y6m	6y3m-8y7m
Non-verbal IQ	**Mean**	**108.21**	**113.39**	**112.85**
	SD	8.52	10.36	11.25
	Range	90-125	90-125	90-125
Spelling (standardised scores)	**Mean**	**80.25**	**105.35**	**100.28**
		6.38	7.84	6.01
		64-89	92-120	93-118
Spelling age	**Mean**	**7y4m**	**10y3m**	**7y5m**
	SD	6.49	17.5	6.82
	Range	6y-8y6m	8y4m-13y5m	6y2m-9y
Reading (standardised scores)	**Mean**	**78.92**	**110.21**	**102.39**
	SD	8.6	12.59	6.34
	Range	54-89	92-142	92-118
Reading age	**Mean**	**7y5m**	**11y2m**	**7y8m**
	SD	6.58	21.39	9.66
	Range	6y-8y6m	8y6m-14y5m	6y9m-9y6m

Reading task

Stimuli

There were 32 words in this list, sixteen regular past tense verbs (RPT) and 16 one-morpheme words (OM). Thirteen of each word type was taken from a list devised by Treiman and Cassar (1996). To increase items, three RPTs and three OMs from spelling List B (see below) were added: *killed, turned,* and *covered*, and *third, child* and *friend*. The lists were matched pair-wise on log frequency (+/- 0.5) (Carroll, Davis, and Richman, 1971), final consonant cluster, and length (+/- 2 letters). For example, *tuned* (log frequency = 1.81) was matched to *brand* (log frequency = 1.71). See Appendix B1 for a full list of the stimuli.

Procedure

The one and two morpheme words were randomised and presented in Arial font size 22, three words per line (see Appendix B2). Children were asked to read the words from left to right, going down the page until the end. There was no time limit. If they did not know a word, they were told to guess, and failing that, to leave out the word and move on. The children's responses were recorded directly onto a response sheet, and tape recorded for later checking.

Spelling tasks

Stimuli

List A. Regular past tense and one-morpheme words (Treiman and Cassar, 1996)

Twenty-six words from the original Treiman and Cassar (1996) spelling list formed the basis of this test. The plural items were omitted, leaving 13 RPTs and 13 OMs. Seven items in each category ended in a /t/ sound, and six in ended in a /d/ sound. These 26 words had all been part of the reading test (see above). In addition, in Analysis 1, two RPTs and two OMs from the reading test were used.

This test was analysed in two ways:

Analysis 1. Omission of prefinal and final consonants

Treiman and Cassar (1996) showed that children aged 6-7 years are more likely to leave out either the prefinal or the final consonants, or both, for one-morpheme words like *brand* (e.g., the '*n*' and '*d*' in *brand*) than for regular past tense verbs, like *rained.* They argued that this phenomenon occurred because children apply their morphological knowledge to spelling, so are aware that regularly inflected verbs are made up of two parts. Consequently, they are less likely to make final consonant omissions on these words because they are attempting to represent both parts of the word. The rationale for including this test here was that many of the children in the DR and SA-RA groups had spelling ages of between 6 and 7 years, so could feasibly make the types of errors Treiman & Cassar (1996) described.

It was hypothesised that if the dyslexic children were less sensitive to morphology, there should be no difference in the number of consonant omissions they made between RPTs and OMs. Conversely, the normally developing children, who may be more sensitive to morphology, should perform like the children in Treiman and Cassar's (1996) study and follow the tendency to omit final consonants more frequently from OMs than RPTs.

In this analysis, thirty words from the reading test (15 RTPs and 15 OMs) were used. Two words from the reading test, *third* and *covered*, were excluded because in these words the written consonant '*r*' is not pronounced in standard spoken English. Consequently, if a child missed out the '*r*' in spelling, it could not be taken as evidence that they had omitted a consonant.

Analysis 2. Use of the –ed ending

This analysis was carried out to see if the dyslexic children were less likely than the other groups to use the correct ending on RPTs relative to their spelling accuracy on the ending of OMs.

Twenty-six words from the original Treiman and Cassar (1996) study were used (13 RPTs and 13 OMs). This was because the additional items included in Analysis 1 were contained within List B (based on Nunes et al., 1997a, see below), and the results of both List A and B were combined for analyses later in the experiment.

Procedure

The words were randomised and presented three times: just on their own, then in a sentence context, then on their own again (e.g., *baked*...we *baked* a cake...*baked*) (see Appendix B3). Children wrote their spellings in small booklets, one word per side. This stopped them from referring back to previously spelled words. Children in the two control groups were administered spelling tasks in class groups and the dyslexic children were administered the spelling tasks individually or in small groups.

Coding

Analysis 1. The spellings did not have to be orthographically correct; all plausible spelling attempts were included for analysis and the letters used to represent the final sound of the words were coded. Following Treiman and Cassar (1996), spellings were coded as:

A if only the prefinal consonant was present (e.g., tuned → tune);

B if only the final consonant was present (e.g., tuned → tued);

AB if both the prefinal and final consonants were present;

BA if the prefinal and final consonants were reversed (e.g., tuned → tudn);

X if the spelling contained neither the prefinal or final consonant (e.g., tuned → tuy).

Analysis 2. Again, the spellings did not have to be orthographically correct; all spelling attempts were included for analysis. The word endings were then coded as:

1. Correct ending used (e.g., baked → backed)
2. *-ed* spelled *d* (e.g., baked → bakd)
3. *-ed* spelled *t* (e.g., baked → bakt)
4. t spelled *d* (e.g., connect → conecd)
5. *d* spelled *t* (e.g., blond → blont)
6. final consonant omission (e.g., blond → blon)
7. *-ed* addition (e.g., blond → bloned)
8. incorrect letter phonetically plausible (e.g., tuned → tunede)
9. incorrect letter phonetically implausible (e.g., tuned → tunth)

List B. Regular past tense verbs, irregular past tense verbs, and one-morpheme words (based on Nunes et al., 1997a)

This list, based on one devised by Nunes et al. (1997a) was used to investigate whether the dyslexic children were less accurate than the control groups at using the correct ending (*-ed*) on RPTs than they were at using the correct ending on IPVs and OMs.

Nunes et al. (1997a) found that between the ages of 7-8 (the age of the SA-RA group) normally developing children go through a period in which they over-generalise the *–ed* ending to IPVs and OMs. Consequently, a further purpose of this test was to assess whether the dyslexic children used 'morphological strategies' in spelling (i.e., correctly allocating *-ed* to RPTs and not over-generalising to IPVs and OMs) to the same extent as SA-RA controls.

There were 30 words, comprising 10 regular past tense verbs, 10 irregularly inflected past tense verbs, and 10 one-morpheme words. Half of the words in each of the three categories ended in a /t/ sound and half ended in a /d/ sound. The three types of words were matched on: (a) frequency (log frequency +/- 0.5) (Carroll, Davies & Richman, 1971); and (b) number of phonemes. The IPVs and OMs were also matched on letter length and final consonant cluster (FCC). Only 8 of the RPTs were matched to the IPVs and OMs on FCC. This was because there are no regular past tense verbs ending in the sounds /lt/ or /nt/. A full list of the stimuli can be found in Appendix C1.

Procedure

The words were randomised and presented to children in a sentence format (see Appendix C2). The children wrote their responses in spelling booklets, one word per side.

Coding

The children's spellings were sorted into the three groups (RPTs, IPVs, and OMs), and coded in one column as either completely orthographically correct (i.e., stem and ending correct), or incorrect. In a second column, they were coded in the same way as Analysis 2 for List A.

Results

Reading task

The results of the reading task are shown in Table 4.1.2.

Table 4.1.2. The number of correct reading responses to regular past tense verbs and one-morpheme words

		DR	CA	SA-RA
Regular past tense	Mean	7.82	15	9.28
verbs	S.D.	4.15	1.6	4.38
(max = 16)	Range	0-14	11-16	0-16
One-morpheme	Mean	8.53	15.35	10.1
words	S.D.	5.08	1.0	5.0
(max = 16)	Range	0-16	12-16	0-16

The table shows that all children read the OMs more accurately than the RPTs. A repeated measures ANOVA was carried out, with word type (OM vs. RPT) as the within factor and group (DR, SA-RA, CA) as the between factor. There was an effect of word type, $F\ (1,81) = 7.41$, $p < 0.01$ and an effect of group, $F\ (2,81) = 27.11$, $p < 0.0001$, but no interaction. Planned comparisons between groups found the CA group was more accurate on both word types compared to the other two groups ($p = 0.00001$). There was no difference between the dyslexic and SA-RA groups.

Within group planned comparisons showed the DR and CA groups read both types of words equally well, but the SA-RA group was better at reading OMs to RPTs, $F\ (1,81) = 4.7$, $p < 0.03$.

The results show that the dyslexic children are not disproportionately worse at reading regular past tense verbs relative to one-morpheme words in comparison to children of the same reading and spelling age.

Spelling tasks

List A (Analysis 1). Final and prefinal consonant omissions in spelling regular past tense and one-morpheme words

The number of X and BA spellings were negligible, and so these were collapsed into one category of 'other'. The results are shown in Table 4.1.3.

Table 4.1.3. The number of times children represented both final consonants, the final consonant, the prefinal consonant, or produced other endings on the regular past tense verb and one-morpheme word spelling task

			DR	CA	SA-RA
Regular	AB	Mean	11.6	14.87	11.7
past tense	Both final	S.D.	4.1	0.35	3.4
verbs	consonants	Range	1-15	14-15	3-15
(max = 15)	A	Mean	0.9	0.03	0.7
	Prefinal only	S.D.	1.3	0.2	1.6
	(e.g., faced >face)	Range	0-4	0-1	0-8
	B	Mean	2	0.07	2.3
	Final only	S.D.	3	0.3	2.8
	(e.g., faced > fad)	Range	0-12	0-1	0-8
	Other	Mean	0.5	0.03	0.3
	(e.g., faced > fa;	S.D.	0.9	0.2	0.5
	faced > fadc)	Range	0-3	0-1	0-2
One-	AB	Mean	11.7	14.7	11.3
morpheme	Both final	S.D.	4.2	0.8	0.8
words	consonants	Range	2-15	12-15	2-15
(max = 15)	A	Mean	0.9	0.2	0.4
	Prefinal only	S.D.	2.1	0.6	0.8
	(e.g., brand>bran)	Range	0-9	0-2	0-3
	B	Mean	1.9	0.1	3.1
	Final only	S.D.	2.7	0.3	3.1
	(e.g., brand > brad)	Range	0-12	0-1	0-12
	Other	Mean	0.5	0	0.2
	(e.g., brand > bra)	S.D.	1.1	0	0.5
		Range	0-4	0-0	0-2

The results show that both the DR and SA-RA groups were more likely to omit prefinal consonants than final consonants. The CA group was at ceiling on their spelling of final consonants, and so their scores were not analysed further.

A repeated measures ANOVA with just the DR and SA-RA groups was carried out on the number of A and B spellings for both RPTs and OMs. The within factors were word type (RPT and OM) and consonant position (A and B) and the between factor was group (DR and SA-RA).

There was no main effect of word type, $F\,(1,54) = 0.57$, ns, or group, $F\,(1, 54) = 0.19$, ns, but there was a main effect of consonant position, $F\,(1, 54) = 25.3$, $p < 0.0001$. There were no interactions between any of the factors. The results show that both the SA-RA and DR groups were more likely to represent the final rather than the prefinal consonant on both RPTs and OMs.

These results mirror those of Treiman and Cassar (1996), who found that children in grades 1, 2, and 4 were more likely to represent the second consonant of a final consonant cluster than the first consonant of a final consonant cluster for both OMs and RPTs.

They also found final consonant omissions were more frequent on OMs than on RPTs among first graders (aged approximately 6 years), but that 2^{nd} and 4^{th} graders made equivalent numbers of A and B errors on these words. The children in the present study were similar to the 2^{nd} and 4^{th} graders because there was no interaction between word type and consonant position. This suggests that after two or three years of schooling, children represent both consonants of a final consonant cluster equivalently for both OMs and RPTs.

List A (Analysis 2). Endings used on regular past tense and one-morpheme words

Preliminary analysis revealed some differences in the DR and SA-RA children's accuracy at spelling the ending of /t/ and /d/ sound ending words. However, these two groups were not consistently poor at one sound over another across word types, nor was one group consistently better than the other on a particular sound, so it was decided to collapse /t/ and /d/ sound ending words together for further analysis in order to increase number of items. The number of times the correct ending was used on the OMs and RPTs are shown in Table 4.1.4.

Table 4.1.4. The number of times the correct ending was used on regular past tense verbs and one-morpheme words

		DR	CA	SA-RA
Regular past tense verbs (max = 13)	Mean	4.96	12.07	6.85
	S.D.	3.6	1.18	4.62
	Range	1-13	9-13	0-13
One-morpheme words (max = 13)	Mean	9.21	11.32	8.1
	S.D.	2.9	1.78	2.9
	Range	4-13	8-13	0-13

These data show that there was large variability within both the dyslexic and SA-RA groups for both categories of words. Some children were at ceiling in their use of the *–ed* ending on RPTs, or the correct *–t* or *–d* ending on OMs, whereas others were extremely poor.

The DR group was far worse at spelling the endings of RPTs compared to the endings of OMs, and they were poorer than the SA-RA group on these endings. Conversely, they appeared better than the SA-RA controls on their spelling of OM endings.

A repeated measures ANOVA was carried out with group as the between factor (DR, CA, and SA-RA) and word type as the within factor (OMs and RPTs). There was a main effect of group, $F(2,81) = 38.63$, $p < 0.0001$, and word type, $F(1,81) = 11.34$, $p < 0.001$, and there was a group x word type interaction, $F(2,81) = 9.55$, $p < 0.0001$.

Planned comparisons between groups found the main group effect occurred because the CA group was better than both the DR and SA-RA groups on both RPTs, (CA vs. DR: $F(1,81) = 58.55$, $p < 0.0001$; CA vs. SA-RA: $F(1,81) = 31.51$, $p < 0.0001$) and OMs (CA vs. DR: $F(1,81) = 9.33$, $p < 0.003$); CA vs. SA-RA: $F(1,81) = 21.71$, $p < 0.0001$). The CA superiority was most marked for regular past tense verbs, and was far greater between the CA and DR group than the CA and SA-RA group.

The source of the word x group interaction occurred because the DR group was poorer than the SA-RA group on RPTs, $F(1,81) = 4.15$, $p <0.05$, but the same on OMs, $F(1,81) = 2.57$, $p = 0.11$.

Within group planned comparisons showed a further source of interaction came from the DR group performing more poorly on RPT endings compared to OM endings, $F(1,81) = 27.24$, $p < 0.0001$, whereas there was no difference in the SA-RA and CA groups' performance on the two word types (SA-RA: $F(1,81) = 2.35$, $p = 0.1$; CA: $F(1,81) = 0.854$, $p = 0.36$).

The key finding from the above analyses was that the dyslexic children were very impaired at spelling the ending of regular past tense verbs correctly, in comparison to their spelling on the endings of one-morpheme words, and in relation to the SA-RA group.

List B. Regular verbs, irregular verbs, and one-morpheme words (based on Nunes et al., 1997a).

The children were not worse at one type of sound over another on any category of word, so the /t/ and /d/ sound words were collapsed together to increase number of items per word category and improve power. The mean scores for the endings used on each type of word are shown in Table 4.1.5.

Table 4.1.5. Mean number of correct endings for the three word types

		DR	CA	SA-RA
Regular past tense	Mean	3.89	9.1	5.71
verbs	S.D.	3	1.16	3.64
(max = 10)	Range	0-9	6-10	0-10
Irregular past	Mean	8.03	9.25	7.03
tense verbs	S.D.	1.91	1.04	2.67
(max = 10)	Range	4-10	6-10	2-10
One-morpheme	Mean	7.96	9.68	7.5
words	S.D.	2.18	0.67	1.97
(max = 10)	Range	1-10	8-10	2-10

The results show that while the CA group represented the endings of all three word types correctly, the DR and SA-RA groups were poorer at representing the *–ed* ending on RPTs compared to the endings on IPVs and OMs. This discrepancy was particularly pronounced for the dyslexic children. The data also show that the DR and

SA-RA groups exhibited high variability in their spelling accuracy on all types of words.

A repeated measures ANOVA, with word type as the within factor (RPT, IPV, OM) and group as the between factor (DR, CA, and SA-RA) was carried out. There was an effect of group, $F(2,81) = 37.43$, $p < 0.001$, and word type, $F(1,81) = 23.82$, $p < 0.0001$, and a word x group interaction, $F(2,81) = 7.72$, $p < 0.001$.

Planned comparisons between groups showed that the main group effect occurred because the CA group was superior to the other groups in their spelling of RPTs (CA vs. DR: $F(1,81) = 48.39$, $p < 0.0001$; CA vs. SA-RA: $F(1,81) = 20.49$, $p < 0.0001$), IPVs (CA vs. DR: $F(1,81) = 5.2$, $p < 0.03$); CA vs. SA-RA: $F(1,81) = 17.31$, $p < 0.0001$), and OMs (CA vs. DR: $F(1,81) = 13.54$, $p < 0.001$); CA vs. SA-RA: $F(1,81) = 21.87$, $p < 0.0001$).

The word x group interaction was because the DR group was poorer than the SA-RA group on RPT endings, $F(1,81) = 5.9$, $p <0.02$, but the same on IPV endings, $F(1,81) = 3.53$, $p = 0.06$ and OM endings, $F(1,81)$ 0.9, $p = 0.32$.

Planned comparisons within groups found the effect of word-type was due to the DR group's poorer performance on the RPTs compared to both IPVs, $F(1,81) = 32.67$, $p < 0.0001$, and OMs, $F(1,81) = 40.537$, $p < 0.0001$. They performed similarly on IPVs and OMs, $F(1,81) = 0.067$, $p = 0.8$. The SA-RA group was worse on the RPT endings compared to OM endings, $F(1,81) = 7.79$, $p < 0.01$, but not IPVs, $F(1,81) = 3.22$, $p = 0.08$. The CA group performed similarly on all three word types.

The results of this analysis mirror those found on Analysis 2 of List A. The dyslexic children were impaired in spelling the *–ed* ending compared to the SA-RA group. They were also poorer on the endings of RPTs than they were on IPVs and OMs.

Summary of spelling data

The main findings are:

(1) In comparison to children of the same age, the DR group was poorer at spelling the ending of all word types, but they were particularly impaired on regular past tense endings;

(2) In comparison to younger children matched on reading and spelling age, the DR children were more impaired in their spelling of the regular past tense verb ending. This finding cannot have been an artefact of poorer ability to represent the endings of words per se, because they were equal to the SA-RA children at representing the final sound on one-morpheme words.

The children's performance on Lists A and B were compared. There was a correlation between the children's use of correct endings for regular past tense verbs (DR: $r = 0.731$, $p < 0.01$; SA-RA: $r = 0.726$, $p < 0.01$; CA: $r = 0.53$, $p < 0.01$). For one-morpheme words, there was a correlation for the DR group ($r = 0.57$, $p < 0.01$) and the CA group ($r = 0.55$, $p < 0.01$), but not the SA-RA group ($r = 0.022$, $p = 0.9$). In List A, the SA-RA group was the same on the endings of RPTs and OMs, but on List B they were worse on the RPTs than OMs. Although the words in List A were of lower frequency than those in List B, the frequencies were equivalent for both word types and so the relative easiness of List B should have had no differential effects on one-morpheme words compared to regular past tense verbs. On List B, the regular past tense verbs were longer in letter length than the one-morpheme words (mean of 6.5 vs. 4.83). However, this letter length difference also occurred between regular past tense and irregular verbs, so it is unlikely that the letter length difference was a source of their different performance on one-morpheme words between on the two tests.

The lists were combined to increase power, resulting in 23 words per category. The final 23 items were calculated by adding the 13 regular past tense verbs from List A with the 10 from List B, and the 13 one-morpheme words from List A with the 10 from List B. The scores of the children's spellings on regular past tense verbs and one-morpheme words when the two lists were combined are shown in Table 4.1.6.

Table 4.1.6. Mean number of correct endings for regular past tense verbs and one-morpheme words for the combined lists

		DR	CA	SA-RA
Regular past tense verbs (max = 23)	Mean	8.86	21.17	12.57
	S.D.	6.2	2.05	7.68
	Range	1-22	16-23	1-23
One-morpheme words (max = 23)	Mean	17.17	21	15.6
	S.D.	4.5	2.2	3.5
	Range	5-23	16-23	6-21

In order to assess the performance of the children when the two lists were combined, a repeated measures ANOVA was carried out with group as the between factor (DR, CA, and SA-RA) and word type as the within factor (RPTs vs. OMs). There was a main effect of group, $F\,(2,81) = 45.83$, $p < 0.0001$, and word type, $F\,(1,81) = 25.26$, $p < 0.0001$, and there was a group x word type interaction, $F\,(2,81) = 11.17$, $p < 0.0001$.

Planned comparisons between groups found the main group effect occurred because the CA group was better than the DR and SA-RA groups on both RPTs, (CA vs. DR: $F\,(1,81) = 62.64$, $p < 0.0001$; CA vs. SA-RA: $F\,(1,81) = 30.56$, $p < 0.0001$) and OMs (CA vs. DR: $F\,(1,81) = 16.19$, $p < 0.0001$); CA vs. SA-RA: $F\,(1,81) = 32.24$, $p < 0.0001$). This result is similar to when the lists were analysed separately.

The source of the word x group interaction occurred because the DR group was poorer than the SA-RA group on RPTs, $F\ (1,81) = 5.7$, $p < 0.02$, but the same on OMs, $F\ (1,81) = 2.73$, $p = 0.1$. This is similar to the results from the separate lists.

Within group planned comparisons showed a further source of interaction came from the DR group performing more poorly on RPTs compared to OMs, $F\ (1,81) = 42$, $p < 0.0001$. The SA-RA group was also poorer on RPTs compared to OMs, $F\ (1,81) = 5.58$, $p < 0.03$. The CA group was no different on the two sets of words, $F\ (1,81) = 0.019$, $p = 0.9$.

When the lists were combined, the main findings remained the same. The dyslexic children were markedly poorer at spelling the *–ed* ending of regular past tense verbs compared to younger children of the same spelling and reading age, but no different to them at spelling the ending of one-morpheme words.

An analysis of the children's errors was carried out to assess why the dyslexic children underused the *–ed* ending.

Analysis of errors made on regular past tense verb endings and one-morpheme word endings

The number of errors made by the three groups of children was calculated. The percentages of types of errors made were calculated by dividing the numbers of each type of error (per word type) by the total number of errors for regular past tense and one-morpheme words respectively. These data are shown in Table 4.1.7.

Table 4.1.7. The types of errors made by the three groups on regular past tense verbs

		DR		CA		SA-RA	
Type of error		**OM**	**RPT**	**OM**	**RPT**	**OM**	**RPT**
TOTAL NUMBER OF ERRORS (max = 23)	Mean	5.8	14.14	2	1.8	7.4	10.43
	S.D.	4.5	6.2	2.2	2	3.6	7.7
	Range	0-18	1-22	0-7	0-7	2-17	0-22
Phonological:	Mean	-	67.6%	-	66.15%	-	62.66%
i.e., -d on /d/ sound ending and -t on /t/ sound ending	S.D.		21.88		44.82		33.79
words (e.g., raced>rast, rained> raind)	Range		21.4 -100		0-100		0-100
Generalisation:	Mean	49.75%	-	33.80%	-	53.99%	-
i.e., use of –ed on one morpheme words.	S.D.	4.089		40.38		33.7	
	Range	0-100		0-100		0-100	
t-d confusion,	Mean	14.21%	11.59%	11.9%	0%	25.95%	12.85%
(e.g., rained>raint).	S.D.	24.83	13.57	28.63	0	29.69	17.14
	Range	0-90	0-50	0-100	0	0-100	0-50
Omission of final consonant	Mean	14.86%	10.4%	4.8%	2.08%	7.75%	6.5%
(e.g., rained>rain)	S.D.	24.6	13.6	12.87	7.7	15.82	13.97
	Range	0-100	0 - 42.86	0-50	0 - 33	0 - 57	0 - 55.56
Phonologically plausible ending	Mean	7.5%	3.9%	16.42%	1.4%	5.8%	7.1%
but incorrect letter used (e.g., rained>rainde)	S.D.	19.8	7.2	35.7	5.35	12.24	20.51
	Range	0-100	0-25	0-100	0-25	0-50	0-100
Phonologically implausible	Mean	10.1%	6.42%	0.89%	1.78%	6.46%	3.68%
ending used (e.g. rained>ranp)	S.D.	17.5	9.7	4.7	9.44	12.49	7.08
	Range	0-55	0-30	0-25	0-50	0-50	0-25

Table 4.1.7 shows that the CA group made very few errors on regular past tense or one-morpheme words, so they were dropped from subsequent analyses.

Total errors

A repeated measures ANOVA, with group (DR vs. SA-RA) as the between factor, and word (RPTs vs. OMs) as the within factor was carried out on total errors. There was no difference between the two groups in total number of errors made on both lists combined, F (1,54) = 1, p = 0.3. Overall, the children made more errors on RPTs, F (1,54) = 27.2, p < 0.0001. There was a word x group interaction, F (1,54) = 5.89, p < 0.02, because the dyslexic children made more errors than the SA-RA group on RPTs, but the SA-RA group made more errors on OMs.

Phonetic endings on regular past tense verbs

The dyslexic group was more likely than the SA-RA controls to spell the ending of RPTs with a phonetic ending (i.e., *-t* on /t/ sound ending words and *–d* on /d/ sound ending words), but this did not reach significance, t (54) = 0.65, p = 0.518.

Generalisation of –ed endings to one-morpheme words

There was no difference between groups on generalisations of the *–ed* ending to one-morpheme words, t (54) = -0.42, p < 0.67.

Other errors

A series of repeated measures ANOVAs were carried out on the other errors. For each error type, the within factor was word (RPT vs. OM) and the between factor was group (DR vs. SA-RA).

t/d confusion errors

There was no difference between the groups on the proportion of t-d confusion errors made, F (1,54) = 1.6, p = 0.2. However, both groups made proportionally more t-d confusion errors on OMs than RPTs, F (1,54) = 6.9, p = 0.01. There was no interaction, F (1,54) = 3.1, p = 0.08, which suggests that the DR group was not less sensitive than the SA-RA group to the t-d contrast.

Omission of final consonant

Although the DR group made a higher proportion of omissions on both RPTs and OMs compared to the SA-RA group, this was not significant, F (1,54) = 1.9, p = 0.17. Both groups made a higher proportion of omissions on OMs compared to RPTs, but this was not significant, F (1,54) = 1.2, p = 0.27. The word x group interaction was not significant, F (1,54) = 0.4, p = 0.5.

Phonologically plausible but incorrect endings and phonologically implausible errors

The children made very few of these errors, and there were no significant main effects or interactions.

Summary of error analysis

The analysis of errors shows that the DR group did not make more of a particular type of error compared to the SA-RA control group. The majority of the dyslexic children's errors on regular past tense verbs comprised phonetic endings. The next most common error was t-d confusion, followed by omission of the final *–ed* ending.

Similarly, the majority of the SA-RA groups' errors on regular past tense verbs comprised phonetic endings, followed by t-d confusion errors, then omissions.

Investigation of morphological strategies in spelling of the *–ed* ending

Nunes et al. (1997a) found that once children become aware of the *–ed* ending, they employ a strategy of generalising it to irregular verbs and over-generalising it to one-morpheme words. They then restrict their use of *–ed* to irregular verbs, and Nunes et al. argue this is an important stage because it shows children understand the difference between nouns and verbs. Finally, children reach a 'correct' stage, in which they do not make generalisations to irregular verbs. From the previous analysis, the DR group did not make fewer *–ed* generalisations to one-morpheme words compared to SA-RA controls. However, a different picture might emerge when generalisations to irregular verb endings are investigated.

If the DR group is quantitatively similar to the SA-RA group, they should use the *–ed* ending less often on irregular past tense verbs than on one-morpheme words. If, however, they differ from the SA-RA children in their relative use of the *–ed* ending between irregular past tense verbs and one-morpheme words, this would suggest that their spelling strategy differs qualitatively from the SA-RA group. The CA group, who is near the 'correct' stage, should make very few over-generalisations.

The number of children in each group who generalised the *–ed* ending to one-morpheme words and irregular verbs from List B is shown in Table 4.1.8. The mean number of generalisations made per group is shown in Table 4.1.9.

Table 4.1.8. The number of children in each group who made one or more generalisations of *-ed* to irregular verbs and over-generalisations of *–ed* to one-morpheme words in List B

Type of generalisation	DR	CA	SA-RA
Irregular verbs (e.g., lost>losed)	12 (43%)	13 (46%)	15 (54%)
One-morpheme (e.g., child > chiled)	10 (36%)	5 (18%)	17 (61%)

Note: Percentages are shown in parentheses.

Table 4.1.9. The mean number of generalisations of *–ed* to irregular verbs and over-generalisations of *–ed* to one-morpheme words made by each group in List B

Type of generalisation		DR	CA	SA-RA
Irregular verbs	Mean	1.03	0.75	2.25
(e.g., lost>losed)	S.D	1.55	1.04	2.67
(max = 10)	Range	0-6	0-4	0-8
One-morpheme	Mean	0.71	0.28	1.7
(e.g., child > chiled)	S.D	1.11	0.66	1.9
(max = 10)	Range	0-4	0-2	0-7

The data from the two tables above show that, compared to the DR and CA groups, a higher proportion of SA-RA children made generalisations of the *–ed* ending to both irregular verbs and over-generalisations to one-morpheme words. In addition, the mean number of generalisations and over-generalisations made by each child in the SA-RA group was higher than for the other groups. Nearly half the CA group children made at least one generalisation of the *–ed* ending to irregular verbs, but far less made one or more over-generalisations to one-morpheme words. The dyslexic children were intermediary between the SA-RA and CA groups in terms of the numbers of generalisations to irregular verbs and over-generalisations to one-morpheme words.

A repeated measures ANOVA was carried out with group as the between factor (DR, SA-RA, CA), and word as the within factor (IPV vs. OM). There was a main effect of word, as all children made more generalisations to irregular verbs compared to one-morpheme words, F (1,81) = 9.56, $p < 0.003$, and group, because the SA-RA group made more generalisations to both word types compared to the other groups F (2,81) = 7.23, $p < 0.001$, but there was no word x group interaction.

Planned comparisons between groups showed the SA-RA group made more generalisations to irregular verbs, and over-generalisations to one-morpheme words compared to both the DR group (IPV: F (1,81) = 5.8, $p < 0.02$; OM: F (1,81) = 7.7, $p < 0.01$) and the CA group (IPV: F (1,81) = 8.87, $p < 0.004$; OM: F (1,81) = 15.72, $p < 0.0002$). There was no difference in number of generalisations to either word type between the DR and CA groups.

Within group contrasts showed the SA-RA group made more *–ed* generalisations to IPVs compared to OMs, F (1,81) = 4.71, $P < 0.03$. The CA group also made more generalisations to IPVs compared to OMs words, but the difference was just short of significance, F (1,81) = 3.54, $p < 0.06$. The DR group performed similarly on both IPVs and OMs, F (1,81) = 1.69, $p = 0.2$.

These data show that the SA-RA group appeared to be using morphological spelling strategies; they over-generalised the *–ed* ending to both IPVs and OMs but were more likely to do this for IPVs. The DR group, however, used a predominantly phonological strategy, and although they made generalisations, they were not more likely to do so on irregular verbs.

Discussion

In this experiment, the three groups were compared on their reading and spelling of regular past tense and one-morpheme words.

The data from the reading task suggest no differences exist between the SA-RA and DR groups. Furthermore, the dyslexic children did not make more errors on regular past tense verbs compared to one-morpheme words.

This finding does not correspond to Elbro's (1989) data, in which 15 year-old dyslexic teenagers misread more inflectional endings than 9 year-old children. However, these teenagers were also poor on spoken measures of morphology so could have had more generalised language impairments than the dyslexic children in this study and been more severely dyslexic. The data reported here also contradict the findings of Henderson & Shores (1982) and Temple (1997), although it is difficult to make direct comparisons to their data because they carried out case studies with no control groups.

On the spelling tasks, it was clear that the dyslexic children were poorer at representing the *–ed* ending, even when compared to children with the same reading and spelling level.

The reason why a difference should exist between reading and spelling can be accounted for by the fact that single word reading is generally easier than single word spelling, and involves less complex processing (Ehri, 1997). Indeed, Funnell (personal communication, January 2003) has suggested that difficulties with morphology exhibited by developmental and acquired dyslexics are more likely to be found in tasks with high levels of processing at output, like spelling, rather than higher levels of processing at input, like reading.

The analysis of spelling errors showed that the dyslexic children made proportionally similar types of errors to the SA-RA group; they were not more likely to use implausible endings, or make t-d confusions.

An interesting finding was that although the dyslexic children did omit more inflectional endings from regular past tense verbs compared to the SA-RA group, this difference was not significant. This does not support the finding that dyslexic children have a greater tendency than normally developing children to leave off inflectional endings (Johnson & Grant, 1989; Smith-Lock, 1991). In these studies, omissions of inflected endings relative to omissions on the endings of one-morpheme words were not compared. When their incidence of final consonant omissions on both inflected and one-morpheme words are considered, as was the case in this experiment, no differences emerged. This suggests that the incidence of omissions of inflected endings reported in the case study literature are actually an artefact of a general tendency to leave off final consonants in spelling.

When the spelling lists were combined, the SA-RA group showed a trend towards making more over-generalisations of the *–ed* ending to one-morpheme words compared to the DR group, but this was not significant. However, when a more detailed analysis was carried out on the children's use of the *-ed* ending on irregular past tense verbs and one-morpheme words (List B), the dyslexic children differed from the SA-RA group. They were less likely than the younger normally developing children to generalise their use of *–ed* to irregular verbs and one-morpheme words. Furthermore, while the normally developing children made more over-generalisations to irregular verbs compared to one-morpheme words, there was no difference for the DR group.

This could be interpreted as demonstrating that the SA-RA group have some awareness of the difference between nouns and verbs, and so are between Stages 3 and 4 on Nunes et al.'s model. The CA group was practically at ceiling in their use of the –*ed* ending, but nevertheless they still made generalisations. They followed the trend of making more generalisations to irregular verbs, so are between Stages 4 and 5 on Nunes et al.'s model. The dyslexic children, who do not appear to use morphological and grammatical knowledge in spelling to the same extent as the SA-RA group, are between Stages 2 and 3.

The figures for generalisations and over-generalisations reported here are higher than those quoted by Nunes et al. (1997a). For instance, in their session A, when they tested 363 children aged between 6y6m and 8y6m (equivalent to the SA-RA's chronological age and DR group's reading age), 34% made a generalisation of *–ed* to irregular verbs. In the current study, the incidence of this was 54% for SA-RA children, and 46% for dyslexic children. One reason for the higher numbers reported here could be that no filler items containing non /t/ and /d/ sound endings were included in the spelling test. Consequently, because a third of the words ended in *–ed*, the children could have been more attuned to using the *–ed* ending. However, if this had been the case, more children might have been expected to use this ending, and individual children who over-generalised *–ed* should have done so more often. While around half the SA-RA and DR children over-used the *–ed* ending, very few used it on the majority of irregular verbs and one-morpheme words.

It is important to investigate the causes of the dyslexic children's less frequent use of the *–ed* ending, because this type of impairment could generalise to other types of morphological spelling (e.g., derivations). As many words in English are produced from the inflection and derivation of base forms, difficulties with spelling morphologically complex words compared to one-morpheme words creates a barrier to literacy.

There are a number of possibilities that could account for the dyslexic children's poor use of the *–ed* ending, and these will be explored in the remainder of the chapter.

The first possibility is that their lower use of *–ed* is an artefact of general difficulties with remembering orthographic patterns in written language. In English, many words are not spelled according to their sound. The ability to read and spell comprises two main components: the ability to convert phonemes into graphemes, and the ability to remember spelling patterns that do not always correspond to phonemes. The final phonemes on regular past tense endings do not have clear one to one correspondences with a grapheme. In the case of /d/ sound ending regular past tense verbs, children can use *–d* or *–ed*. On /t/ sound ending regular past tense verbs, they can use *–t* or *–ed*, so the degree of mismatch between phoneme and grapheme is greater in the case of /t/ sound ending regular past tense verbs. If the dyslexic children's problem lies in their ability to use a grapheme that deviates greatly from the phoneme, they should have been worse at /t/ sound regular past tense endings. However, the data from both spelling lists showed that dyslexic children were not more inclined to misspell the ending of /t/ sound ending regular past tense verbs in relation to /d/ sound ending regular past tense verbs. Consequently, their difficulty appears to lie in choosing the correct grapheme when there is more than one option.

It is unlikely that the dyslexic children are less aware of the *–ed* ending compared to the SA-RA group, because these groups were matched on reading level and would have had similar levels of exposure to words with an *–ed* ending. If anything, the dyslexic children should have had more exposure than the younger children, but they did not appear to have benefited from this. Rather, it could be that when faced with two spelling options, dyslexic children are more inclined to opt for the most frequent and direct phoneme-grapheme correspondence.

Choosing between two graphemes (i.e., *-t/-d* or *–ed*) can be accomplished by relying on orthographic knowledge. As children progress in reading, they become exposed to an increasing number of regular past tense verbs. It could be that children remember the whole word form of many regularly inflected past tense verbs, and it is this memorisation that affects how accurately they represent the *–ed* ending. They may be better at spelling the ending of irregular verbs and one-morpheme words because they are less ambiguous in their spelling. Consequently, children with a better memory for whole word patterns, as measured by their ability to read and spell irregular words (i.e., where phoneme-grapheme correspondences are opaque, such as in *wrist* and *meringue*) will be better at spelling regularly inflected past tense forms than those with poorer memories for whole word spelling patterns. This possibility will be investigated in Experiment 2.

EXPERIMENT 2

A comparison between dyslexic children, spelling and reading age matched children and chronological age matched children on their levels of orthographic knowledge

Method

Participants

As in Experiment 1.

Reading task

The purpose of this task was to assess whether the dyslexic children, SA-RA controls and CA controls differed in their ability to read regular words, irregular words, and non-words. The regular words and non-words were used as an indicator of the children's phoneme-grapheme knowledge. The irregular words were used as an index of memory for whole words.

Stimuli

The list comprised 16 regular words (i.e., could be read correctly using common grapheme-phoneme correspondences, such as *shelf, part,* and *dentist*); 16 irregular words (i.e., could not be read using common grapheme-phoneme correspondences, such as *island, meringue,* and *wolf*); and 16 non-words (e.g., *tegwop, golthom,* and *nart*).

The two real word lists were matched on frequency (pairwise log frequency of +/- 0.5) and length (pairwise +/- one letter). It was not possible to match for number of phonemes; the regular words had more phonemes (4.44 compared to 3.5). The non-words were matched as closely as possible to both sets of real words on letter length, and to the regular words on number of phonemes. A full list of the words and non-words can be found in Appendix D1.

Procedure

The regular and irregular words were randomised and presented together, and the non-words were presented on their own. The word lists were written on sheets of white A4 paper, three words per line (Arial 22 font) (Appendix D2). Children were tested individually and asked to read each word aloud. They were told to have a go at all words, and to guess if they were unsure.

Coding

The children's responses were marked as correct or incorrect.

Spelling task

Stimuli

The words from the reading test were presented as a spelling test. The regular and irregular words were randomised and presented together. The non-words were presented as a spelling test on their own (Appendix D3).

Procedure

The control groups were administered the spelling tests in their class groups. The dyslexic children were given the tests individually or in small groups. All children were asked to write the words in spelling booklets, one word per page and to attempt each word even if they did not know how to spell it. The words were read aloud three times as single words, but the two homophones in the list (*sword* and *island*) were clarified (e.g., *sword,* as in the *sword* used by a soldier, *sword*; *island,* as in a desert *island, island*).

Coding

All words were coded as right or wrong. In addition, the following analysis was carried out in order to gain a more sensitive measure of the children's phoneme-grapheme ability and their orthographic processing.

Regular words and non-words. One point was given if the correct phoneme was represented in the correct place, and 0.5 point if the correct phoneme was in the wrong place. The maximum possible score was 68.

Irregular words. There were 2 scores here. Firstly, the number of phonemes represented was calculated, with 1 point if the correct phoneme was represented in the correct place, and 0.5 point if the correct phoneme was in the wrong place. The maximum score was 57. Secondly, 1 point was awarded if an irregular segment of the word was represented. The maximum score was 16.

Results

Reading task

The number of words the children read correctly for all three word types (N=16) are shown in Table 4.2.1.

Table 4.2.1. Number of words read correctly

		DR	CA	SA-RA
Regular words	Mean	11.96	15.71	12.42
(max = 16)	S.D	3.7	0.76	3.1
	Range	1-15	13-16	5-16
Non-words	Mean	8.14	14.21	9.2
(max = 16)	S.D	4	2.0	3.6
	Range	0-15	7-16	2-16
Irregular words	Mean	7.1	12.64	7.3
(max = 16)	S.D	4.1	1.33	3.3
	Range	0-14	10-15	1-12

A repeated measures ANOVA was carried with word type (regular, irregular, non-word) as the within factor and group (DR, CA, SA-RA) as the between factor. There was an effect of word type, F (2,162) = 103.29, p < 0.00012, and group, F (2,81) 30.46, p < 0.0001, and a word x group interaction, F (4, 162) = 3.45, p < 0.02. Planned comparisons between groups showed the CA group outperformed both the dyslexic and SA-RA groups on all three word types (p = 0.0001). There were no differences between the DR and SA-RA groups on any of the three word types.

Within group planned comparisons revealed that the source of the interaction was because groups performed differentially on the three word types. The DR group was better on regular words compared to irregular words, F (1.81) = 82.79, p < 0.0001, and non-words, F (1,81) = 67.52, p < 0.0001, and there was no difference between the non-words and irregular words. The SA-RA group was also better on regular words compared to irregular words, $F\,(1,81) = 91.54$, $p < 0.0001$, and non-words, $F\,(1,81) = 45.67$, $p < 0.0001$, but unlike the DR group they were also better on non-words compared to irregular verbs, $F\,(1,81) = 10.99$, $p < 0.0001$. The CA group was better on regular words compared to irregular words, $F\,(1,81) = 33.5$, $p < 0.0001$, and non-words, $F\,(1,81) = 9.91$, $p < 0.002$. They were also better on non-words compared to irregular words, $F\,(1,81) = 7.4$, $p < 0.005$.

Spelling task

The number of words the children spelled correctly for all three word types (N=16 per group) are shown in Table 4.2.2.

Table 4.2.2. Number of words spelled correctly

		DR	CA	SA-RA
Regular words	Mean	9.92	14.35	9.32
(max = 16)	S.D	3.9	1.09	3.2
	Range	1-15	13-16	3-15
Non-words	Mean	8.9	13.07	8.3
(max = 16)	S.D	3.9	2.5	4.0
	Range	1-15	8-16	0-14
Irregular words	Mean	2.6	10.57	3.17
(max = 16)	S.D	2.13	2.1	2.21
	Range	0-6	6-16	0-6

Table 4.2.3. Number of phonemes correctly represented in the spelling of regular words, irregular words, and non-words and number of silent letters represented for irregular words

		DR	CA	SA-RA
Regular words Max = 68	Mean	60.83	68.76	60.2
	S.D.	8.1	1.48	6.25
	Range	32-68	63.5-68	46-68
Non-words Max = 68	Mean	58.07	65.03	57.35
	S.D	8.2	3.3	8.8
	Range	34.5-67	55-68	34-66.5
Irregular words Max = 57	Mean	48.75	53.82	47.8
	S.D.	6.4	1.55	6.1
	Range	29.5-57	49.5-56	32.5-56
Silent letters Max = 16	Mean	3.96	11.3	3.89
	S.D.	2.54	2.38	2.23
	Range	0-10	8-16	0-7

A repeated measures ANOVA was carried out on the number of phonemes represented, with word (regular, non-word, and irregular) as the within factor and group (DR, CA, SA-RA) as the between factor. The was a significant effect of word, F (2, 162) = 569.7, $p < 0.0001$, and group, F (2,81) = 13.69, $p < 0.0001$, and there was a word x group interaction, F (4, 162) = 2.52, $p < 0.05$.

Planned comparisons between groups showed that the CA group was better than the SA-RA and DR groups on all word types. There was no difference between the SA-RA and DR groups on any of the word types.

Within group planned comparisons mirrored the findings from the analysis on the number of words spelled correctly. All three groups correctly represented more phonemes on regular verbs compared to non-words (DR: F (2,81) = 16.12, $p < 0.0001$; CA: F (2,81) = 29.31, $p < 0.0001$; SA-RA: F (2,81) = 17.83, $p < 0.001$), and irregular words (DR: F (2,81) = 409.29, $p < 0.00001$; CA: F (2,81) = 625.01, $p < 0.0001$; SA-RA: F (2,81) = 433.82, $p < 0. 00001$). They were also all better on non-words compared to irregular words (DR: F (2,81) = 131.52, $p < 0.0001$; CA: F (2,81) = 190.36, $p < 0.0001$; SA-RA: F (2,81) = 137.64, $p < 0.00001$).

As in the analysis on number of words correct, the source of the interaction was unclear, so another repeated measures ANOVA was carried out on the DR and SA-RA groups alone. This showed an effect of word, F (1,54) = 260.46, $p < 0.0001$ but no group effect, F (1,54) = 0.155, $p = 0.7$ or interaction, F (1,54) = 0.051, $p = 0.9$. The interaction most probably occurred because the CA group was proportionately better at representing the number of phonemes in regular words compared to irregular words (68.76 – 53.82 = 14.94) than compared to non-words and irregular words (65.03 – 53.82 = 11.21), in relation to the other groups.

For the silent letters, a one way ANOVA was carried out. There was a difference between groups, $F(2,81) = 88.661$, $p < 0.0001$. Post hoc LSDs found the CA group was better than the SA-RA and DR groups, both of whom performed similarly to each other.

Discussion

The main aim of Experiment 2 was to assess whether the dyslexic children's poor use of the *–ed* ending on regular past tense verbs was due to weaker memorisation of whole word forms, which was measured by seeing how well the dyslexic children on read and spelled irregular words. These data show the dyslexic children were no worse at reading or spelling regular words, irregular words and non-words compared to children with the same reading and spelling level. This would suggest that the dyslexic children in this study have similar levels of phoneme-grapheme and grapheme-phoneme knowledge, and orthographic knowledge, to the SA-RA children.

In previous research, a traditional and robust finding has been that dyslexic children are generally poorer at non-word reading compared to children of the same reading level (e.g., Felton & Wood, 1992; Wimmer, 1996; see Rack, Snowling & Olson, 1992, for a review). The lack of a difference in the current experiment could be due to changes that have occurred in the teaching of reading over the past five years. The introduction of the National Literacy Strategy (NLS) (DfEE, 1998) in 1998 has ensured that children receive daily training in phonics. Consequently, the children in this study, who were all educated in schools following the NLS, may have had better phoneme-grapheme and grapheme-phoneme skills than children who were tested over five years ago. Phonological skills help children to grasp segmentation and phoneme-grapheme correspondences, which directly helps regular word reading and spelling.

Good regular word reading boosts exposure to print and facilitates the development of orthographic representations for irregular words. All the dyslexic children in this study were receiving some form of additional specialist support for their literacy difficulties, and the core of such remediation places a heavy emphasis on phonics training.

Less work has been carried out comparing dyslexic children with reading level controls on non-word spelling and this has tended to find no differences between groups (Bruck, 1988).

As stated at the end of Experiment 1, use of the *–ed* ending involves choosing, at either an implicit or explicit level, between two plausible graphemes. In making this choice, children could refer to their knowledge of whole word patterns. An impairment in this domain could account for poor use of the *–ed* ending. However, the dyslexic children did not appear to be impaired in knowledge of whole word forms in relation to the SA-RA group.

A further strategy children could use in making this choice between graphemes would be to use their knowledge of morphology. Nunes et al. (1997a) suggested that children gradually learn to apply their knowledge of morphological rules when spelling the *–ed* ending. More specifically, they argued children learn to apply the abstract rule that if the base sound of the inflected form remains the same as the present tense version, then an *–ed* ending should be used (e.g., *cover-covered*). However, if the base sound is different from the inflected past tense form, the ending should be spelled phonetically, which is what occurs for irregular past tense verbs (e.g., *lose-lost*). As this rule is not taught in schools, Nunes et al. (1997a) argued that children most probably implicitly acquire it. Awareness of this rule obviously requires phonological awareness of sound changes in words, so poorer phonological skills could underpin what on the surface appear to be morphological impairments.

The finding in Experiment 1 that the SA-RA group made more generalisations of the *–ed* ending to one-morpheme and irregular verbs would suggest that they are using a morphological rule for placing *–ed* endings on regular past tense verbs. However, because their knowledge of the rule is under-developed, they over-applied this rule to other types of words. The dyslexic children's lower incidence of generalisations, relative to the SA-RA group in this study, could suggest that they were not using a morphological rule in spelling regular past tense *–ed* endings, or, if they are, they are not doing so to the extent that they should for their spelling level.

In order to use rules in spelling, children need to know them. The next study assesses the morphological awareness of the children.

Given the importance of morphological awareness for literacy development in general, and for the reading and spelling of inflected forms in particular, it is possible that dyslexic children might have deficiencies in this domain, over and above their well documented deficits in phonology (Snowling, 2001). However, although a robust finding has been that dyslexic children are poorer on spoken tasks of inflectional morphology compared to children of the same age (Brittain, 1970; Bryant et al., 1998; Doehring, Trites, Paterl & Fiedorowicz, 1981; Egan & Tainturier, 2003; Joanisse, Manis, Keating, & Seidenberg, 2000; Vogel, 1983; Wiig, Semel, & Crouse; 1973; though see Smith-Lock, 1991, for a null result), these impairments could be attributed to their poorer literacy skills. It has been suggested that initial difficulties with reading reduces exposure to morphologically complex words in print, which in turn may affect the development of dyslexic children's morphological awareness in spoken language (Bryant et al., 1998; Fowler & Liberman, 1995). In order to show that dyslexic children have deficits in morphological processing, they need to be compared to children with similar reading levels.

When this design is employed, results have been discrepant. Most studies have found dyslexic children are no worse on morphological awareness tasks (Bryant et al., 1998; Carlisle, 1987; Elbro, 1989; Joanisse et al., 2000). However, it appears to depend upon the wider linguistic abilities of the dyslexic children. Joanisse et al. (2000) found that when the dyslexic children in their study were split into three sub-groups (delayed, phonological, and language impaired), the language impaired children, whose vocabulary scores were poor and who scored low on a speech perception task, performed less well than the reading-age matches on a Berko-type (1958) task. Similarly, Ben-Dror, Bentin, & Frost (1995) found dyslexic children were poorer on morphological tasks compared to younger children matched on vocabulary.

Performance on morphological awareness tasks are related to phonological awareness, because they often involve asking children to generate morphologically related forms that differ phonologically from their base form, such as *hang-hung*. On tasks of derivational morphology, poor readers are worse on morphological items that involve a phonological change (Fowler & Liberman, 1995). Consequently, it is important to also assess the groups' phonological awareness, because if the dyslexic children were poorer than SA-RA group on measures of morphology in spoken language, the extent to which this might be an artefact of poor phonological awareness needs to be assessed.

Many studies have shown that dyslexic children are more impaired than children of the same reading level on tasks involving phonological processing (Snowling, 1995; Stanovich & Siegal, 1994). Deficiencies in phonological processing could exert a direct effect on spelling of the past tense *–ed* ending because the past tense *–ed* ending is not phonologically salient (Kean, 1989). A more indirect effect of phonology on morphology is that children with poor phonological skills could be less likely to access the rule that phonological changes between the stem and inflected form indicate that an irregular ending should be used, whereas phonological constancy between the stem and inflected form indicate that an *–ed* ending should be used.

In Experiment 3, the three groups of children will be compared on their levels of both phonological and morphological awareness.

EXPERIMENT 3

A comparison between dyslexic children, spelling and reading age matched children, and chronological age matched children on measures of phonological awareness and morphological awareness.

Method

Participants

As in Experiments 1-2.

Phonological tasks

Phoneme deletion

This task involved speaking a word, and asking the child to repeat the word, leaving out a particular sound (e.g., say '*brand*'. Now say it again without the /n/). After a practice trial, children were presented with 12 items. They had to leave out four initial sounds, four medial sounds, and four final sounds. The numbers of correct responses were recorded. These items can be found in Appendix E.

Non-word repetition

This task involved the child repeating non-words. The non-words were taken from Gathercole, Willis, Baddeley & Emslie's Nrep (1994). The purpose of this test was to assess children's phonological short-term memory. To make the task harder, some non-words from the Nrep were combined together to make longer items. There were two items at each level of number of syllables, ranging from two syllables (e.g., *tafflest*) to seven syllables (e.g., *woogalamisperplister*). The non-words were read out and the child had to repeat them accurately. A practice trial was included before the main test. Testing was stopped after children could not repeat four consecutive items.

The total number of syllables repeated was used as the final score, rather than number of items. This was because pilot data showed some children made errors on a 3 or 4 syllable item but correctly repeated 5 or 6 syllable items. In such cases, it is difficult to know how to accurately score 'nonword span', as a child who makes an error on a 3 syllable non-word, but goes on to correctly do 4 and 5 syllable non-words before failing on 6 syllable non-words, is clearly not as good as a child who makes no errors at all until 6 syllable non-words. This test can be found in Appendix F.

Digit span

This forward digit span test was used as an additional assessment of children's short-term memory. There were 8 levels, ranging from two digits to nine digits, with two items at each level. A child's digit span was recorded as the last set of digits for which they succeeded on both items. The digits were read out at a rate of 1 per second. A practice trial was included before the main test. This task is shown in Appendix G.

Morphological awareness tasks

Inflecting nonsense words

This was adapted from Berko (1958). Children were presented with pictures of stick figures performing fictitious tasks and asked to supply the missing non-word. There were 3 practice items, and 11 experimental items. 8 of the experimental items involved the child providing a regular past tense form (e.g., Here is a man who knows how to /gʌk/. He is /gʌkɪŋ/. He did the same thing yesterday. What did he do yesterday?

Yesterday he ____?), one was a plural, and 2 were 3rd person present tense. Children's responses were marked right or wrong. The full test can be found in Appendix H.

Morphological judgement

This task was adapted from Rubin's (1988) 'comes from' test, which was originally devised by Derwing (1976). It involves asking children if there is a smaller word in another word (e.g., is there a smaller word in '*kissed*' that means something like '*kissed*'?). After a practice trial, there were 12 items (6 two-morpheme and 6 one-morpheme).

In order to be sure that children were using knowledge of morphological relations rather than a strategy that involved removing the final consonant and seeing if a word was left, two controls were put into place. The first was that three words that sounded like another real word once the final consonant was removed (*tent, beard, card*) were included in the one-morpheme words. The second control was achieved by putting the one and two morpheme words into couplets for scoring purposes. The children had to get both sets of a couplet correct to gain a score of one. A full list of these stimuli can be found in Appendix I.

Sentence analogy

This task was devised by Nunes et al. (1997a). It involved the experimenter saying a sentence, and then saying exactly the same sentence but changing the tense of the verb. The change was either from present to past tense or past to present (e.g., *John helps Mary. John helped Mary*). Another sentence was then spoken, in which the tense of the verb was the same as the first of the original two sentences, and the child is asked to carry out exactly the same transformation on this sentence (e.g., *John sees Mary. John ?*

Mary). The sentences were presented by two finger puppets, so in the second instance, the child had to help the second puppet with the second set of sentences. There were 4 practice sentences, and 8 experimental sentences. Two of the experimental sentences involved generating a regular past tense form. The other sentences involved producing present tense forms or irregular past tense forms. Children's responses were marked right or wrong. The full version of this test is in Appendix A.

General Procedure

All children were assessed individually on the phonological and morphological awareness tasks.

Results

Phonological awareness

The children's scores on the phonological awareness tasks are shown in Table 4.3.1.

Table 4.3.1. Children's scores on each of the phonological awareness tasks, the phonological awareness tasks combined, and digit span.

TASK		DR	CA	SA-RA
Phoneme deletion (max = 15)	Mean	6.21	9.42	6.03
	S.D.	2.18	2.04	2.7
	Range	1-10	5-12	0-12
Non-word repetition (max = 54 syllables)	Mean	22.07	35.42	27
	S.D.	11.17	11.9	13.31
	Range	4-48	14-54	5-54
TOTAL of phoneme deletion and non-word repetition (max = 69)	Mean	28.28	44.85	33.03
	S.D.	11.9	12.6	14.3
	Range	11-55	22-66	9-60
Digit span	Mean	4.8	6	5.2
	S.D.	0.7	1.3	1.11
	Range	4-6	4-9	4-7

One way ANOVAs showed there were differences between groups on all three tasks (Phoneme deletion: $F(2,81) = 18.85$, $p < 0.0001$; repetition of nonsense words: $F(2,81) = 8.6$, $p < 0.001$; digit span: $F(2,81) = 11.44$, $p < 0.0001$). Post hoc LSDs found that the CA group was superior to both the DR and SA-RA groups on all tasks. There was no difference between the DR and SA-RA groups on any of the tasks, or on the combined phonological awareness score. However, when the total phonological awareness scores are observed, it can be seen that there is a trend in which the dyslexic children were poorer than the SA-RA controls, who in turn were poorer than the CA controls.

Morphological awareness tasks

The mean number of correct responses for each of the morphological awareness tasks are shown in Table 4.3.2

Table 4.3.2. Mean scores on each of the morphological awareness tasks, and the morphological awareness tasks combined.

		DR	CA	SA-RA
Inflectional morphology	Mean	8.32	10.21	7.7
(max = 11)	S.D.	3.8	1.57	3.4
	Range	0-11	5-11	0-11
Morphological judgement	Mean	4.6	5.6	4.3
(max = 6)	S.D.	1.7	0.86	1.4
	Range	1-6	3-6	0-6
Sentence analogy (max = 8)	Mean	5.2	6.9	3.5
	S.D.	1.6	1.2	2.1
	Range	0-8	4-8	2-8
Total (max = 25)	Mean	18.2	22.8	15.7
	S.D	5.8	2.7	5.2
	Range	6-25	16-26	6-25

One-way ANOVAs were carried out on each type of task. For inflectional morphology production, there was a difference between groups, F (2,81) = 4.66, p <0.01. Post-hoc LSDs showed that the CA group was better than the SA-RA group and similar to the dyslexic group. The dyslexics performed similarly to the SA-RA group. For morphological judgement, there was a difference between groups, F (2,81) = 7.08, p <0.01. Post hoc LSDs showed the CA group was better than both the DR and SA-RA groups on this task, and there was no difference between the DR and SA-RA groups. For sentence analogy, there was a difference between groups, F (2,81) = 27.26, p < 0.001. Post-hoc LSDs showed that the CA group was better than the other two groups, and the dyslexics scored higher than the SA-RA group. Post hoc LSDs on the composite morphological awareness score showed the CA group was better than the SA-RA and DR groups, and these latter two groups did not differ.

The results on the phonological and morphological awareness tasks suggest that the dyslexic children, while impaired for their age on both phonological and morphological awareness, do not have deficits in these linguistic domains in relation to younger children with the same reading and spelling level.

Although the results of Experiments 2-3 have shown no differences in task performance that could account for the dyslexic children's poorer use of the *–ed* ending, it could be that some differences emerge when the factors that impact upon use of the *–ed* ending are explored.

Contributions to the variance in spelling of regularly inflected verbs

Using regression analysis, Nunes et al. (1997a) found that measures of morphological awareness were predictive of children's use of the *–ed* ending. Egan and Tainturier (in preparation) also found this, but in addition showed that orthographic knowledge exerts a stronger effect on spelling the *–ed* ending compared to morphological awareness.

From the experiments reported here, measures of children's morphological awareness (total of all three morphological awareness tasks), orthographic knowledge (use of silent letters in spelling irregular words + reading of irregular words) and phonological awareness (Nrep + phoneme deletion) were calculated. In addition, the total number of times children correctly used the *–ed* ending on regular past tense verbs on list (a) and list (b) was calculated. As there were four spellings used in both lists (A and B) (friend, child, turned, killed), these were removed from List A, leaving 13 words per category from List A. Correlations between correct use of the *–ed* ending, and morphological awareness, phonological awareness and orthographic awareness are shown in Table 4.3.3.

Table 4.3.3. Correlations between correct use of the *–ed* ending and morphological awareness (morph), phonological awareness (phon) and orthographic awareness (ortho) for each group.

	DR	CA	SA-RA
-ed ending & morph	0.234	0.28	0.536*
-ed ending & phon	0.275	0.08	0.29
-ed ending & ortho	0.58**	0.615**	0.56**

** correlation significant at 0.01 level, *correlation significant at 0.05 level.

From these correlations, it can be seen that only orthographic awareness relates to correct use of the *–ed* ending for the DR and CA groups. This means that children who were better at memorising irregular patterns were also better at correctly using the *–ed* ending. For the SA-RA group, both orthographic awareness and morphological awareness related to use of the *–ed* ending.

Hierarchical regression analysis was carried out to look at the factors contributing to the use of the *-ed* ending. A stepwise multiple regression was carried out on each group, with number of correct *–ed* endings on regular past tense verbs as the dependent factor, and morphological awareness, orthographic awareness and phonological awareness as the predictors. A summary of the regression analyses for each group is shown in Table 4.3.4

These results show that for the DR and CA groups, only orthographic knowledge emerged as a predictor of spelling of the *–ed* ending. However, for the SA-RA group, both orthographic and morphological knowledge was a predictor. Interestingly, phonological awareness was not a significant factor in any group.

Table 4.3.4. Summary of hierarchical analysis

Variable	*B*	*SE B*	*β*
		DR	
Orthographic awareness	0.614	0.169	0.58***
		CA	
Orthographic awareness	0.39	0.098	0.615***
		SA-RA	
Step 1			
Orthographic awareness	0.83	0.24	0.56**
Step 2			
Orthographic awareness	0.6	0.25	0.405*
Morphological awareness	0.59	0.25	0.36*

Note: DR group: R^2 = 0.336, Adj R^2 = 0.31; phonological and morphological factors were not significant predictors (*B* = 0.03 and 0.017 respectively). CA group: R^2 = 0.378, Adj R^2 = 0.35; phonological and morphological factors were not significant predictors (*B* = 0.21 and 0.2 respectively). SA-RA group, R^2 = 0.421, Adj R^2 = 0.375; phonological factors were not a significant predictor (*B* = 0.05). *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Discussion

The results on the phonological awareness tasks show the dyslexic children were poorer, though not significantly so, compared to children of the same reading level. This does not concur with previous studies which suggest dyslexic children are deficient, relative to this group, on phonological awareness (e.g., Fawcett & Nicolson, 1995a; Snowling, 1995; Stanovich & Siegal, 1994). The reason for this could be that the dyslexic children in this study were all receiving support for their literacy problems, and part of this remediation involves phonological awareness training. In addition, all children were taught in schools adhering to the Literacy Hour, which boosts phonological skills in children.

On morphological awareness, the dyslexic children were poorer than the CA group, which corresponds to previous research (Brittain, 1970; Bryant et al., 1998; Doehring et al., 1981; Joanisse et al., 2000; Vogel, 1983; Wiig et al., 1973). In comparison to the SA-RA group, they were not more impaired, which is similar to the conclusions of some previous research (Bryant et al., 1998; Carlisle, 1987; Elbro, 1989).

The regression analysis showed that all the children's orthographic awareness had an impact on their spelling of the *–ed* ending. This suggests that for all the children in the study, orthographic awareness is still developing, as suggested by Beers and Beers (1992). For all groups, there was a surprising lack of effect of phonological awareness on spelling of the *–ed* ending. However, this could be because the contribution of this skill relates to phoneme-grapheme correspondences in spelling, and all children were good at applying the correct grapheme to unambiguous endings (i.e., one-morpheme words).

The interesting finding to emerge was that only the SA-RA group was affected by morphological awareness. This shows that morphological awareness is still developing for them, and exerts an impact on the spelling of *–ed* endings. This finding concurs with that of Nunes et al. (1997a) and Sénéchal (2000). In the DR and CA groups, morphological awareness had no effect, but the reason for the lack of effect in the two groups is likely to be different. The CA group may have largely consolidated their inflectional morphological awareness in spoken language, and they were at ceiling in their use of *–ed* of regular past tense verbs. However, for the DR group, their levels of morphological awareness were similar to the SA-RA group, but this did not have an effect on spelling of the regular past tense *–ed* ending. This finding leads to the possibility that that although the DR group's levels of inflectional morphological knowledge was similar to the SA-RA group, they differed from this group in their ability to apply morphological rules to spelling.

When looking at use of rules in spelling, it is difficult to make conclusions from data based on real word stimuli. This is because children's correct use of the regular past tense ending on real words is open to dual interpretation: they could be applying a rule, or they could be memorising the whole word's spelling pattern.

In order to test the application of rule use, non-words need to be employed. In Experiment 4, a new task was devised in which non-words were administered in different syntactic contexts.

EXPERIMENTS 4a and 4b

A comparison between dyslexic children, reading and spelling level matched children, and chronological age matched children on their ability to apply morphological rules in non-word spelling

Introduction

In literacy research, the conventional way of investigating rule-use has been to give children non-words to read and spell (e.g., Frith, 1980). The rationale has been that children's ability to spell non-words provides a 'pure' demonstration of their ability to use alexical phoneme-grapheme rules (though see Campbell, 1985; Goswami, 1988; Nation & Hulme, 1998).

The non-word paradigm has been used to assess morphological spelling strategies in three studies (Kemp & Bryant, 2003; Nunes Carrahar, 1985; Nunes et al., 1997b).

Nunes Carrahar (1985) carried out a study with Brazilian children to investigate the Portuguese suffixes *–ice* and *–sse*. Although these endings sound the same, *-ice* is a derivational morpheme used in abstract nouns, and *-isse* is an inflectional morpheme for the subjunctive. The children had to write non-words embedded in sentence contexts, and the results showed that younger children spelled the *–ice/-isse* ending on non-words the same way, whereas older children spelled the endings differently depending upon the grammatical status of the verb.

In English, Nunes et al. (1997b) applied the non-word paradigm to assess children's use of morphological spelling rules. Three groups of children aged 8, 9, and 10 were given written sentences (which were also read aloud) and their task was to write the past tense form of the pseudo-verb in the sentence. One of the five sentences in the regular pseudo-verb condition was: 'We like *deaving* very much. When we next go to London we will *deave*. The last time that we went there we /divd/ too.' If children spelled /divd/ as *deaved*, this was taken as evidence that they were using knowledge of morphology in spelling. There were also five sentences in the irregular pseudo-verb condition, one of which was: 'Our neighbours are going to *neave* their dog this morning. We wanted to *neave* our dog two weeks ago, but in the end we /neft/ him yesterday'. If children spelled /neft/ as *neft*, rather than *neffed*, this showed that, at some level, they were aware of the rule that when a past tense verb deviates phonologically from its present tense form, it is spelled irregularly (e.g., *lose-lost*). Nunes et al. (1997b) found all the children were more likely to use an *–ed* ending on the end of regular pseudo-verbs and a phonetic ending on the end of irregular pseudo-verbs. There was also a developmental progression; older children used *–ed* on regular pseudo-verbs more than children in the year below.

However, there are two main shortcomings with this study. The first one is that on 3/5 of the regular pseudo-verbs, putting anything other than *–ed* on the end would have produced an illegal spelling string (*deavd, feacht* and *lingd*). Therefore, it could be argued that older children used *–ed* more frequently than younger children because their spelling was more constrained by orthographic conventions (e.g., Cassar & Treiman, 1997). For the irregular pseudo-verbs, using a phonetic ending always generated a legal ending (*neft, fept, prold, draught* and *moght*).

A second problem with the study was that all the pseudo-verbs could be analogised to real words. As children were provided with both the written and oral representations of the pseudo-verbs, they could simply have been spelling the past tense forms of the pseudo-verbs by reference to a similar sounding and looking real verbs.

There is a great deal of evidence to suggest that children and adults do use analogies when spelling non-words (e.g., Campbell, 1985; Goswami, 1988; Nation & Hulme, 1998). Nunes et al. (1997b) acknowledged this possibility, but I would argue that their solution to resolving this source of bias was not extensive enough. They included only two non-analogous irregular verb sentences in their second study (/bʌyp/; /sɑnd/). When these were used, the only group that placed *–ed* on the end of the regular pseudo-verbs more often than the non-analogous irregular pseudo-verbs was the middle age group - the 9-10 year olds. This finding somewhat contradicts the idea that use of *–ed* on regular verbs follows a developmental sequence, although with such a small number of stimuli it is difficult to make too many conclusions. In short, the data from their pseudo-verb study does not provide convincing evidence that children are actually using morphological rules in an explicit way in their spelling of the *–ed* ending.

A third study, by Kemp and Bryant (2003) used a sentence context to see how children and adults applied the plural *–s* ending to non-words (e.g., *Prees.* How many *prees* can you see up there? vs. *Preez.* That man keeps a big *preez* in his cupboard.). If the participants used an *–s* ending in a plural context, and a *–z* ending in a singular context, this was taken to show that they were using morphological rules in spelling. Surprisingly, the results showed that neither children nor adults based their spelling on morphological rules but instead based their spelling on the frequency with which certain letters co-occur in English.

In this experiment, a new non-word spelling task was devised to assess how adults and the three groups of children spelled the same non-words on different occasions when the syntactic context was varied. All the non-words had ortho-phonetic neighbours that could be spelled with either an *–ed* ending or a phonetic ending. This eliminated, to some degree, the likelihood of spellers being biased towards spelling the non-words with one type of ending over another.

If children were using morphological rules in real word spelling, they should spell the non-words with an *–ed* ending when they are presented in a verb context, and with a phonetic ending when they are presented in a noun context. As this study had not been done before on the *–ed* ending in English, an experiment was first carried out on good adult spellers (2nd year university students) (Experiment 4a) to see if they applied morphological rules to the spelling of non-words. On the basis of previous research, which suggests that good adult spellers use morphological knowledge in spelling (e.g., Fisher, Shankweiler, & Liberman, 1985), it was expected that the adults would use knowledge of morphology in spelling the non-words.

The CA group were at or near ceiling in their use of the *–ed* ending for real words, and so it was hypothesised that they would approach the non-word task in an adult-like way (Experiment 4b). Morphological awareness had an effect on the SA-RA group's spelling of the *–ed* ending, and it was expected that the ratio of times they used *–ed* on the non-words in a verb context would be similar to the proportion of times *–ed* was used on real words (around 50%). They were also expected to generalise their use of *–ed* to non-words in a noun context to the same extent that they did for real irregular past tense verbs and one- morpheme words (around 20%).

The main prediction for the dyslexic group was that they would spell the non-words with a phonetic ending most of the time, regardless of context.

Experiment 4a

Method

Participants

Thirty-one 2nd year university students (27 female, 4 male), with a mean age of 22 years 5 months (SD = 5.4 months, range 19 years 5 months to 40 years 4 months) took part in this spelling study. Non-native English speakers and individuals with dyslexia or hearing impediments were excluded.

Stimuli

Fifteen one-syllable non-words were devised by changing the onset of real words. Eight of the non-words ended in a /d/ sound, and seven in a /t/ sound. All of the non-words had phono-orthographic neighbours (i.e., could be spelled by analogy to a real word of the same sound). For example, the non-word /neist/ could be spelled by analogy to *paste, taste, waste, waist,* or to *faced, laced, raced, chased.* The lists of neighbours were generated by entering all possible spellings of the rime into the MRC Psycholinguistic Database. For example, for the non-word /plʌd/, all the ways it could plausibly be spelled on the basis of common phoneme-grapheme rules, were entered (i.e., *-erd, -eard, -ird, -urd, -erred, -irred, -urred,* but not *–ord* from *word*). Archaic forms (i.e., those for which there was no entry in the Oxford dictionary) and swearwords were excluded.

For the fifteen non-words, there was no listwise difference between the number of phono-orthographic neighbours with phonetically spelled endings (mean =5.133, SD

= 3.39, range = 11), or regular past tense endings (mean = 7.26, S.D. = 4.21, range = 17), t (14) = -1.52, ns.

The combined log frequency of the phono-orthographic neighbours was computed using the frequencies from Carroll, Davies, & Richman (1971). There was no difference between the neighbour frequencies for phonetically spelled endings (mean = 2.79, S.D. = 1.33, range = 4.70), or regular past tense endings (mean = 2.05, S.D. = 0.8, range = 2.70) for the non-words, t (14) = 1.85, ns.

The non-words were embedded in two sentence contexts; in one they appeared as a noun (e.g., /neist/... The /neist/ is red.../neist/), and in the other they appeared as a verb (e.g., /neist/... He /neist/ his sweets../neist/). The two sentence contexts for each non-word were separated into two lists, so that each non-word appeared only once in each list. The number of noun and verb contexts were counterbalanced, so half the non-words in each list were in a noun context, and half in a verb context.

Seven filler non-words, embedded in either verb or noun contexts, were included in each list to prevent the participants from deducing the aim of the study. A full list of the non-words, the sentence contexts of the two lists, and the filler items, are shown in Appendix J.

Procedure

The two spelling lists were administered to students in their lecture group three weeks apart. Participants were told they would be asked to write some non-words to dictation. The non-words were read out by the experimenter, first on their own, then in a sentence, then on their own again. The students were told not to write anything until they had heard the non-word three times. Participants wrote their responses in spelling booklets, one spelling per page. At the end of the second spelling task, the participants were asked if they thought they knew what the study was about. None of them guessed the correct purpose of the study.

Coding

The spellings were given a score of 1 if they were spelled phonetically, 2 if they were spelled with an *–ed* and 3 if they were spelled with 'other' endings, such as a final consonant omissions or a phonologically implausible ending.

Results

Incorrect endings (i.e., 'other' endings) were discarded. A score for each participant was calculated by adding up the total number of times they used a phonetic ending and an *–ed* ending in each context. The ratio of how often *-ed* endings were used in each context was computed by dividing the number of *–ed* endings used by the total number of correct endings (i.e., total of phonetic endings and *–ed* endings). The ratios are shown in Table 4.4.1.

Table 4.4.1. Ratio of times adults used the *–ed* ending on non-words in noun and verb contexts

	Noun context	Verb context
Mean	0.25	0.6
S.D.	0.21	0.24
Range	0-0.93	0-1

There is considerable variability in the adult scores. Some used a phonetic ending in both contexts most of the time, whereas others used an *–ed* ending in both contexts most of the time. However, overall the adults were more likely to use the *–ed* ending in the verb context compared to the noun context, $t(30) = 6.12$, $p < 0.001$, which suggests that most of them can apply morphological rules to the spelling of new words.

In order to assess whether dyslexic children are more impaired in using syntactic context compared to the SA-RA and CA groups, the non-word spelling task was administered to these groups (Experiment 4b).

Experiment 4b

Method

Participants

As in Experiments 1-3.

Stimuli

As in Experiment 4a, except that filler items were not used for the children in order to reduce the total number of items they had to write.

Coding

As in Experiment 4a.

Procedure

As in Experiment 4a.

Results

The ratio of times that the *–ed* ending was used on non-verbs in noun and verb contexts was calculated in the same way as described in Experiment 4a. These results are shown in Table 4.4.2.

Table 4.2.2. Ratio of times the three groups of children used the *–ed* ending on non-words in noun and verb contexts

		DR	CA	SA-RA
Noun context	Mean	0.17	0.36	0.25
	S.D.	0.21	0.19	0.21
	Range	0-0.67	0.07-0.73	0-0.62
Verb context	Mean	0.21	0.42	0.3
	S.D.	0.3	0.16	0.25
	Range	0-0.93	0.07-0.8	0-0.83

The results show all children used *–ed* more frequently in the verb context compared to the noun context, but the difference was not large, and all groups used the phonetic ending the majority of the time in both contexts.

A repeated measures ANOVA was carried out, with group (DR, CA, SA-RA) as the between factor and context (noun vs. verb) as the within factor. There was a main effect of context, F (1,81) = 6.8, $p < 0.02$, because when all the groups' scores were combined, they used the *–ed* ending more frequently on non-words in the verb context compared to the noun context, $F\ (1,81) = 6.78,\ 0.01$. However, when planned comparisons were carried out within each group, none of the groups used the *–ed* ending more frequently in the verb context in comparison to the noun context. There was a main effect of group, $F\ (2,81) = 6.27$, $p < 0.02$, because the dyslexic children were less likely to use the *–ed* ending in comparison to CA controls in both the noun context, $F\ (1,81) = 12.01$, $p < 0.001$ and verb context, $F\ (1,81) = 10.02$, $p < 0.002$. The SA-RA group also used the *–ed* ending less often than the CA group in the noun context, $F\ (1,81) = 3.97$, $p < 0.05$, but not the verb context, $F\ (1,81) = 3.0$, $p = 0.08$. There was no difference in the use of the *–ed* ending between the dyslexic and SA-RA groups in the noun, $F\ (1,81) = 2.168$, $p = 0.14$, or verb, $F\ (1,81) = 2.05$, $p = 0.155$, contexts.

Discussion

In these experiments, a novel task was devised to assess whether or not the dyslexic children were less likely to use morphological information when spelling the ending of non-words. It was established in Experiment 4a that adults are affected by syntax when placing verb endings onto non-words. It was expected that the CA group, who were at ceiling in their use of the *–ed* ending on real words, would perform in a similar way to the adults. This is because their correct use of the *–ed* ending on real regular verbs would suggest that they are applying morphological rules to spelling, as suggested by Nunes et al. (1997a). Therefore, it was particularly surprisingly that the CA group was not affected by context in their spelling of non-word endings.

It was also expected that the SA-RA group, whose use of the *–ed* ending on real regular past tense verbs was at around 50% accuracy, would use the *–ed* ending on at least half of the non-word stimuli in the verb context. On the real word spelling lists, the SA-RA group also over-used the *–ed* ending and generalised it to irregular verbs and one-morpheme words between 15 and 20% of the time. Consequently, they were expected to use the *–ed* ending on non-words in a noun context approximately one fifth of the time. However, although they used the *–ed* ending more in the verb context, this was not significant.

It was anticipated that the SA-RA group would have used the *–ed* ending more frequently than the dyslexic group. However, although there was a trend in this direction, it was not significant.

This experiment set out to assess whether or not dyslexic children are poorer at using morphological strategies in spelling compared to control groups. Unfortunately, this question could not be answered because the data raised the question of whether normally developing children aged 6-10 years do, in fact, use knowledge of morphological rules in real word spelling.

The data from Experiments 1-4 show that the dyslexic children only differ from the SA-RA control group on two spelling phenomena: they are poorer at using the *–ed* ending on regular past tense verbs; and they are less likely to follow the normal development sequence, as suggested by Nunes et al. (1997a) of over-generalising this ending to irregular verbs and non-verbs.

The causes of these differences do not appear to be due to poorer orthographic memory (Experiment 2), or poorer phonological and morphological knowledge (Experiment 3) on the part of the dyslexic children. Furthermore, it cannot be concluded whether or not dyslexic children are poorer at applying morphological strategies to spelling compared to control groups, because the results from this experiment, along with the findings of Egan & Tainturier (in preparation), cast some doubt on Nunes et al.'s assertion (1997a) that normally developing children aged 10 and under primarily use morphological strategies in spelling regular past tense verb endings.

In the following experiment, sub-group differences were investigated.

EXPERIMENT 5

Identification of a dyslexic subgroup who have specific impairments in inflectional morphological spelling

Introduction

Experiment 1 established that, as a group, the dyslexic children were poorer than SA-RA controls on spelling the past tense *–ed* ending, and are were less likely to use the *–ed* ending on irregular verbs and one-morpheme words. Experiments 2 and 3 attempted to locate the cause of these differences, but showed there was no difference between the DR and SA-RA groups in knowledge of orthographic patterns, phonological awareness, and morphological awareness.

In all the previous experiments, there was a large spread of scores in the dyslexic group's performance. Consequently, one reason for the difficulty in identifying the underlying causes of their lower use of the *–ed* ending could lie in the variability that exists in the dyslexic group with respect to: (a) spelling of the *–ed* ending, and (b) orthographic knowledge, and morphological and phonological awareness.

The sample appears to contain a mixture of both children whose development of the *–ed* spelling pattern is atypical, along with those who do not have specific problems with the *–ed* ending. Consequently, it could be that poor use of the *–ed* ending is underpinned by different factors for different children. It is well established that differences exist as to the types of difficulties experienced by children with developmental dyslexia (e.g., Boder, 1971, 1973; Castles & Coltheart, 1993). It also appears that the origins of dyslexic-type difficulties differ within the dyslexic population (Ramus et al., 2003a).

Some children could be under-using the *–ed* ending because they are still in what Frith (1985) refers to as the 'alphabetic' stage. Children at this stage have still not consolidated their knowledge of phoneme-grapheme rules, and consequently are not ready to master patterns such as the past tense *–ed* ending. These children should perform similarly to SA-RA controls in their spelling of all the word types used in the study.

A second group would be children whose spelling of one-morpheme word endings is similar or superior to the SA-RA group, but whose use of the *–ed* ending is poorer. This latter group is of particular interest because if they demonstrate difficulties with the *–ed* ending, despite good phonological and morphological skills, it could suggest that they have what on the surface appears to be a specific impairment with inflectional spelling patterns.

Analysis of sub-groups

In order to identify whether sub-groups exist in the dyslexic sample, a measure of difficulty with regular verb endings compared to one-morpheme word endings was calculated by subtracting the amount of times the correct ending was used on regular past tense verbs (from Lists A and B) from the number of times the correct ending was used on one-morpheme words (from Lists A and B).

Most children in the SA-RA and DR groups were better at using the correct ending on one-morpheme words compared to regular past tense verbs, so most of these children should have a positive score. A child with a very high positive score would be very good at spelling one-morpheme word endings but very poor at spelling the *–ed* ending, and could be said to have a specific problem with *–ed* endings. The CA group was mostly equivalent in their spelling of the endings of one-morpheme words and regular past tense verbs, so their scores should be near zero. A child with a high negative score would be one who is poor at using the correct ending on one-morpheme words, but good at using the *–ed* ending on regular past tense verbs. Conceivably, such a child would have the tendency to use *–ed* on both types of words and would be in the over-generalisation stage.

The 'difference' score between one-morpheme words and regular past tense verbs was calculated for each group, and the results are shown in Table 4.5.1.

Table 4.5.1. Use of the correct ending on one-morpheme words and regular past tense verbs, and the difference between the two word types

		DR	CA	SA-RA
(a) One-morpheme words	Mean	17.17	21	15.6
	S.D.	4.5	2.2	3.5
	Range	5-23	16-23	6-21
(b) Regular past tense verbs	Mean	8.8	21.17	12.57
	S.D.	6.2	2.05	7.6
	Range	1-22	16-23	1-23
Difference between (a) and (b) (max =23)	Mean	8.32	-0.17	3.03
	S.D.	7.2	2.4	8.99
	Range	-4 to 20	-6 to 5	-13 to 16

To differentiate groups, the mean 'difference' score for the SA-RA group was used, as this was considered to be representative of the difference in spelling accuracy for endings between the two word types for children with a spelling age of around 7 and a half years of age. In order to isolate those children who were markedly poorer on the –*ed* endings relative to their ability to spell the correct ending of one-morpheme words, the following steps were taken:

(1) A score of 1.65 S.D. (used as this represents the 5th percentile) above the SA-RA 'difference' mean was computed:

Sub-step a: mean = 3.03, S.D. = 8.99, SD x 1.65 = 14.8

Sub-step b: 3.03 + 14.8 = 17.83

As 'difference' scores are whole numbers, this figure of 17.83 was rounded down to 17.

(2) All children with a 'difference' score of =/> 17 were isolated. There were four dyslexic children in this group, but no controls.

The dyslexic group was split into two groups:

1. Dyslexic Group 1 (DG1) (N = 24): Children whose difference in spelling accuracy between the endings on one-morpheme and regular past verbs was within 1.65 S.D. of the SA-RA 'difference' mean.
2. Dyslexic Group 2 (DG2) (N = 4): Children whose difference in spelling accuracy between the endings on one-morpheme and regular past tense verbs was outside 1.65 S.D. of the SA-RA 'difference' mean. In addition, they were within the normal range of the CA group on their spelling of one-morpheme word endings.

The two groups' mean spelling scores for the endings of one-morpheme and regular past tense verbs, and the difference between these two word types, are shown in Table 4.5.2.

Table 4.5.2. The two dyslexic sub-groups' mean spelling scores for the endings of (a) one-morpheme words, (b) regular past tense verbs, and (c) the difference between these two word types

		Dyslexic Group 1 (N=24)	Dyslexic Group 2 (N=4)
(a) One-morpheme words (max = 23)	Mean	16.37	21.7
	S.D.	4.4	0.5
	Range	5-23	21-22
(b) Regular past tense verbs (max = 23)	Mean	9.8	2.75
	S.D.	5.9	1.7
	Range	1-22	1-5
Difference between (a) and (b) (max =23)	Mean	6.5	19
	S.D.	6	1.4
	Range	-4 to 15	17-20

Comparison of DG1 to the SA-RA and CA control groups

Use of the –ed ending in spelling

In order to see whether the removal of the four children with profound difficulties with the *–ed* ending (DG2) changed the main finding that the dyslexic children were poorer than the SA-RA group on their spelling of the *–ed* ending, a repeated measures ANOVA was carried out, with word type (OM vs. RPT) as the within factor, and group (DG1, SA-RA and CA) as the between factor. There was a main effect of group, F (2,77) =

41.47, $p < 0.0001$, and word, $F(1,77) = 18.78$, $p < 0.0001$, and a word x group interaction, $F(2,77) = 7.02$, $p < 0.002$.

Planned comparisons between groups showed that the group effect occurred because the CA group was better than the DG1 and SA-RA groups on both word types ($p = 0.001$). There was no difference between the DG1 and SA-RA groups on *–ed* ending verbs and one-morpheme words.

The word x group interaction was due to the finding that the DG1 and SA-RA groups were both better at spelling the ending of one-morpheme words compared to regular past tense verbs (DG1: $F(1,77) = 24.7$, $p < 0.0001$; SA-RA: $F(1,77) = 6.2$, $p < 0.014$), whereas the CA group was similar on both word types.

Generalisations of –ed to irregular verbs and non-verbs

The number of generalisations of the *–ed* ending to one-morpheme words and irregular past tense verbs (List B) was carried out with the DG1 group to see if they still differed from the SA-RA group on incidence of generalisations. A repeated measures ANOVA was conducted with word (irregular verb vs. one-morpheme word) as the within factor and group (DG1, SA-RA, CA) as the between factor. The results were no different from those reported in Experiment 1.

Impact of morphological awareness in spelling of the –ed ending

A hierarchical regression analysis was conducted on DG1, with *–ed* as the dependent factor, and phonological awareness, morphological awareness, and orthographic knowledge as the predictors. The result was similar to that reported in Experiment 3.

Summary of DG1

The children in DG2 were contributing significantly to the group differences in the use of *–ed* ending, but the DG1 group still differed from SA-RA controls in that they made less generalisations of *–ed* to irregular verbs and one-morpheme words. In addition, morphological awareness did not exert a significant effect on their use of the *–ed* ending in spelling.

Consequently, although the DG1 children used the *–ed* ending on regular past tense verbs to the same extent as the SA-RA children, their spelling does not appear to follow the pattern of normal children.

Examination of DG2

The characteristics of this group was examined more closely in order to determine the underlying processes that could be causing their spelling impairment. Their ages and IQ were within the normal range of the CA group, and their spelling and reading ages were within the range of the SA-RA group. Their characteristics are shown in Table 4.5.3.

Table 4.5.3. The characteristics of DG2, and their scores on standardised tests of non-verbal ability, reading and spelling.

Child	MC	CM	PP	WS
Age	9.08	10	9.05	9.10
Sex	male	female	male	male
Non-verbal IQ (ravens)	110	120	110	125
WRAT 3 spelling % rank	14	7	4	10
Spelling age	7.6	7.5	6.9	7.5
WRAT 3 reading % rank	10	3	12	14
Reading age	7.6	7.2	7.3	7.8

The first step was to examine the types of errors these children made on the *–ed* ending. The proportion of error types made by this group on both *–ed* ending, and one-morpheme words was computed by following the procedure outlined in Experiment 1. These are shown in Table 4.5.4.

Table 4.5.4. Types of spelling errors made by the DG2 and DG1 groups on one-morpheme and regular past tense verbs

	DG2 (n = 4)		DG1 (n = 24)	
	Regular past tense	One morph errors	Regular past tense	One morph errors
Total errors	20.25 (1.7)	1.25 (0.5)	13.12 (6.1)	6.58 (4.4)
Phonetic ending	90.26% (3.58)	-	63.8% (21.36)	-
-ed addition	-	50% (57.73)	-	49.71% (39.09)
t-d confusion	3.6% (4.5)	0%	12.9% (14.16)	16.58% (26.13)
Omission of final consonant	2.38% (2.7)	37.5% (47.87)	11.7% (14.2)	11.09% (17.61)
Phonologically plausible ending	1.1% (2.38)	0%	4.4% (7.7)	8.77% (17.6)
Phonologically implausible ending	2.5% (2.9)	12.5% (25)	7.08% (10.31)	9.66% (16.7)

Note: Standard deviation in parentheses.

When the errors of DG2 are compared to those of DG1 and to the SA-RA group (Experiment 1, Table 4.1.7), the DG2 group made a higher proportion of phonetic errors on regular past tense verbs. They made proportionately less t/d confusion errors on both one-morpheme and regular past tense verbs, and a higher proportion of omission errors on one-morpheme words but not on regular past tense verbs. They were similar to the SA-RA and DG1 groups on number of generalisations of the *–ed* ending to one-morpheme words, and on the number of phonologically plausible and implausible endings.

Overall, the DG2 group did not differ greatly from either the SA-RA or DG1 groups in the types of errors they made; they were just far more likely to spell all words with a phonetic ending.

Comparisons on all tasks

In order to further assess the causes of the DG2 group's lower use of the *–ed* ending, their performance on all tasks was considered. The three areas in which they would be most likely to show impairments were orthographic knowledge, phonological awareness, and morphological awareness. Poor irregular word reading and the ability to represent silent letters in spelling would indicate poor orthographic knowledge. Low total phonological awareness scores would indicate impairments in phonology, and impairments in morphological awareness would be indicated by poor performance on the combined morphological awareness tasks.

Their scores on the full range of tasks used in this study, along with the mean and standard deviation scores for the SA-RA and CA group on these tasks, are shown in Table 4.5.5.

Table 4.5.5. The scores of the DG2 group on the full range of tasks used in Experiments 1-3, along with the mean and standard deviation scores of the SA-RA and CA groups on these tasks

		SA-RA		*CA*		MC	CM	PP	WS
Morphological awareness	max	*Mean*	*S.D*	*Mean*	*S.D*				
Inflecting nonsense words	11	*7.7*	*3.4*	*10.21*	*1.57*	11	**3**	10	11
Morphological judgement	6	*4.3*	*1.4*	*5.6*	*0.86*	6	**3**	**3**	6
Sentence analogy	8	*3.5*	*2.1*	*6.9*	*1.2*	8	**4**	7	8
Total morph awareness	25	*15.7*	*5.2*	*22.8*	*2.7*	25	**10**	20	25
Phonological awareness									
Phoneme deletion	12	*6.03*	*2.7*	*9.42*	*2.04*	6	7	6	9
Nrep syllables	54	*27*	*13.31*	*35.42*	*11.9*	28	4	**11**	34
Total phon awareness	66	*33.03*	*14.3*	*44.8*	*12.6*	34	**11**	**17**	43
Dig Span	n/a	*5.2*	*1.11*	*6*	*1.3*	5	4	5	5
Reading tasks									
Regular words	16	*12.42*	*3.1*	*15.7*	*0.76*	**13**	14	**13**	**13**
Irregular words	16	*9.2*	*3.6*	*12.64*	*1.33*	**9**	**6**	**9**	11
Nonwords	16	*7.3*	*3.3*	*14.21*	*2*	12	**7**	**5**	11
One-morpheme words	16	*10.1*	*5*	*15.35*	*1*	**13**	**7**	**8**	**13**
Two morpheme words	16	*9.28*	*4.38*	*15*	*1.6*	14	**7**	**6**	**9**
Spelling tasks									
Regular words	16	*9.32*	*3.2*	*14.35*	*1.09*	11	11	**5**	12
Irregular words	16	*3.17*	*2.21*	*10.57*	*2.1*	**5**	**0**	**1**	**0**
Silent	16	*3.89*	*2.23*	*11.3*	*2.38*	**5**	**0**	**2**	**2**
Nonwords	16	*8.3*	*4*	*13.07*	*2.5*	13	10	**5**	14
Regular past tense	23	*12.57*	*7.68*	*21.17*	*2.05*	**2**	**5**	**1**	**3**
One-morpheme words	23	*15.6*	*3.5*	*21*	*2.2*	22	22	21	22

Note: Blue font indicates when a child is outside 1.65 S.D. of the CA mean, and red font denotes that the child is also outside 1.65 S.D. of the SA-RA mean.

Children were judged to be impaired when their scores are below –1.65 S.D. of the mean of the CA group, and to have deficits if their scores were below –1.65 S.D of the SA-RA group. On the basis of the three factors likely to impaired (i.e., phonological awareness, orthographic knowledge, and morphological awareness), none of the children had deficits, except for CM, whose non-word repetition score fell outside the –1.65 S.D. range of the SA-RA group mean. However, relative to the CA group, some of the children had impairments. A summary of the children's impairments is shown in Table 4.5.6.

Table 4.5.6. A summary of the children's impairments

Phonological impairment	Orthographic impairment	Morphological impairment
CM	MC	CM
PP	CM	PP
	PP	
	WS	

It can be seen from the above table that all the children were impaired in orthographic skills. CM and PP had additional impairments in both phonological and morphological skills. These findings showed that children who are poor at using the –*ed* ending relative to their good spelling on the ending of one-morpheme words (note that all the children performed at or above the CA mean on these endings) are not a homogeneous group. They all have a key impairment in orthographic skills, but some may have additional difficulties with phonology and morphology. In the case of CM, her poor non-word repetition score indicated that she has quite pronounced difficulties with phonology, and this was reflected in her poor non-word spelling score.

A difficulty with drawing conclusions from the data provided in this sub-group analysis is that the tasks administered to the children were not thorough enough for detailed sub-group analysis, due to the large numbers of children who had to be tested.

Logically, at this point in the research, the next step would have been to investigate the DG2 children's phonological, morphological, and orthographic skills in greater depth. However, this was not feasible because the children were approaching the end of Year 5, and testing would have involved gathering more norms on older groups of CA and SA-RA children. Consequently, it was decided to select new children by screening dyslexic children at the start of Year 5 and identifying those whose spelling of the *–ed* ending was impaired in relation to their use of the correct consonant ending on one-morpheme words. These case studies are described in Chapter 5.

CHAPTER 5

MULTIPLE CASE STUDY OF DYSLEXIC CHILDREN WHO HAVE SPECIFIC DIFFICULTY SPELLING THE REGULAR PAST TENSE *–ED* ENDING.

Introduction

This study aimed to investigate 9-10 year-old dyslexic children who had particular difficulties using the *–ed* ending correctly when spelling regular past tense verbs, in relation to their accurate spelling of one-morpheme word endings. The possible causes of their specific difficulties with inflectional past tense endings were considered by using a wider range of tasks than those used in Experiments 1-4.

Participant Selection

The initial procedure in participant selection involved screening twenty Year 5 dyslexic children. They were recruited in the same way as the dyslexic children in Experiment 1; schools were approached and asked to recommend children in Year 5 who were poor spellers and readers, despite average or above underlying ability. Before screening commenced, school special needs co-ordinators (SENCos) were interviewed about potential participants. This was to ensure that children whose poor literacy could be attributed to extenuating factors (such as social problems, conduct disorders, SLI, and sensory, neurological, or physical impairments) were not assessed.

After obtaining parental consent, the children were screened on four measures: the WRAT 3 reading and spelling tests(Wilkinson, 1993), and spelling Lists A and B from Experiment 1 (adapted from Treiman & Cassar, 1996, and Nunes et al., 1997a respectively). Children whose reading and spelling scores on the WRAT 3 (Wilkinson,

1993) were at or below the 25th centile, and whose 'difference' scores between regularly inflected verb endings and one-morpheme word endings were at or over 17 (the criterion calculated in Experiment 5) were included in the study.

Participants

Three children (AB, MD, and MB), all male, were selected on the basis of these criteria. In addition, one male dyslexic child, JG, who over-applied *–ed* (i.e., used it on irregular verbs and one-morpheme words as frequently as he did on regular past tense verbs) was selected for further study. While JG's spelling profile did not conform to the remit specified at the outset of the study, he was included for two reasons. Firstly, he presented an unusual case, because his spelling pattern differed from those of the dyslexic children in the first study. Secondly, it was thought that further investigation of JG might reveal fundamental differences between him and the other dyslexic children in terms of cognitive abilities, which could further elucidate why certain dyslexic children under-used the *–ed* ending.

All the children were receiving additional literacy support at school. Three of the children, AB, MB, and JG, had a statement of special educational needs for Specific Learning Difficulties (dyslexia). In addition to help received in school, these children were receiving specialist support for one hour a week from a Learning Support Service dyslexia teacher. The children came from middle to lower-middle class backgrounds. None had physical or sensory impairments, though JG had been diagnosed with poor vergence control by an educational optometrist, and he wore glasses with a frosted lens over the right eye for reading. All the children were right handed.

The children were assessed between late January and mid April. Although the aim was to see children for 45-50 minutes once a week, this was not always possible due to factors such as illnesses and school trips. The longest gap between sessions for any one child was two weeks.

Assessments of literacy and underlying ability

All children were assessed on the British Picture Vocabulary Scales (Dunn & Dunn, 1992), which provides a measure of verbal ability, and the Raven's Progressive Matrices (Raven, 1958), which assesses non-verbal ability. They had been administered the WRAT-3 reading and spelling sub-tests during the initial screening (Wilkinson, 1993). The children's scores on these tasks are shown in Table 5.1.

Table 5.1. The children's standardised scores on tests of non-verbal ability, verbal ability, reading, and spelling.

	AB	MD	MB	JG
Age	9y11m	9y10m	10y4m	10y5m
Non-verbal IQ	125	90	110	100
BPVS	137	109	101	107
Spelling*	84 (14)	84 (14)	81 (10)	83 (13)
Spelling age	7y6m	7y6m	7y6m	7y9m
Reading*	81 (10)	90 (25)	89 (23)	78 (7)
Reading age	7y6m	8y6m	8y6m	7y6m

Note: * Standard score on WRAT 3. Percentile rank in parentheses.

All the children were impaired in reading and spelling in relation to their underlying verbal and non-verbal abilities.

Comparison data

The goal of this study was to assess the areas in which the dyslexic children show impaired performance, and so control data was gained for most of the tasks. These data were provided by:

1. SA-RA (n=28) and CA (n=28) control participants from Experiments 1-4.
2. CA controls (n=21) who were studied in a 3rd Year undergraduate project supervised by M-J. Tainturier. They were similar to the four dyslexic children in this study in age (mean age = 10 years 2 months, S.D. = 7.3), and non-verbal ability (Ravens standard score mean = 117.38, S.D. = 8.6).
3. RA (reading age) and CA control data from published sources.

Procedure to assess deviance

A typical procedure to assess deviance from the norm is to set a value of *n* standard deviations from the control mean. Selection of this level is arbitrary, and no value has been used consistently in the literature. In this study, it was decided to select a level of S.D. = 1.65, which corresponds to the fifth percentile in a normal distribution. This level was used in a recent study comparing dyslexic students with CA controls (Ramus et al., 2003a). When the scores of the dyslexic children in this study fell outside the S.D. = 1.65 level for CA controls, this indicated impairment (shown by blue font on tables). When their scores fell outside the S.D. = 1.65 level for SA-RA controls, this was interpreted as a deficit (shown by red font on tables).

MORPHOLOGICAL PROCESSING IN SPELLING AND READING

Spelling of regularly inflected verbs

The reliability of the study was monitored by assessing the children's spelling of the *–ed* ending at different points in time. They were given List B from Experiment 1 (based on Nunes et al., 1997a) on three occasions: at the start of the study, mid-way through and at the end.

Procedure

The spelling test was administered as described in Experiment 1.

Coding

The numbers of times children used the *–ed* ending, a phonetic ending, or made a final consonant omission were calculated. Errors that did not fit into these three criteria were coded as 'other'. There were no difference in the children's performance on /d/ and /t/ sound ending words, so these categories were collapsed.

Control data

Control data came from the SA-RA and CA control groups from Experiment 1.

Results

The children's spellings on each of the three testing occasions are shown in Appendix K. A summary of the results of their spellings are shown in Table 5.2.

TABLE 5.2. Children's spellings on regular past tense verbs, irregular past tense verbs, and one-morpheme words

	SA-RA	CA	AB			MD			MB			JG		
			I	M	F	I	M	F	I	M	F	I	M	F
Regular past tense (max = 10)														
-ed ending	5.71 (3.64)	9.1 (1.16)	**2**	**3**	**4**	**3**	**3**	**4**	**3**	**2**	**5**	8	9	**2**
Phonetic ending	3.35 (3.1)	0.85 (1.1)	**6**	**6**	**4**	**5**	**7**	**5**	**7**	**8**	**5**	**2**	**1**	**8**
Omissions	0.14 (0.44)	0 (0)	**1**	**1**	**2**	**2**	0	**1**	0	0	0	0	0	0
Other	0.14 (0.44)	0.003 (0.18)	**1**	0	0	0	0	0	0	0	0	0	0	0
Irregular past tense (max = 10)														
Phonetic ending	7.03 (2.67)	9.25 (1.04)	10	10	10	9	10	9	8	9	**7**	**2**	**2**	8
-ed ending	2.14 (2.6)	0.75 (1.04)	0	0	0	0	0	1	2	1	**3**	**8**	**8**	2
Omissions	0.17 (0.39)	0 (0)	0	0	0	0	0	0	0	0	0	0	0	0
other	0.007 (0.26)	0 (0)	0	0	0	**1**	0	0	0	0	0	0	0	0
Non-verbs (max = 10)														
Phonetic ending	7.5 (1.97)	9.68 (0.67)	9	**8**	10	10	10	10	9	9	**7**	**2**	**5**	9
-ed ending	1.7 (1.9)	0.28 (0.65)	1	**2**	0	0	0	0	1	1	**3**	**8**	**5**	1
Omissions	0.1 (0.4)	0 (0)	0	0	0	0	0	0	0	0	0	0	0	0
other	0 (0)	0 (0)	0	0	0	0	0	0	0	0	0	0	0	0

I = initial; M = midway; F = final assessment. Blue font indicates scores outside 1.65 S.D. of the CA mean; red font indicates scores outside 1.65 S.D. of the SA-RA mean.

Initial. On regular past tense verbs, AB, MD, and MB performed similarly to SA-RA controls but were impaired compared to the CA group. JG was similar to the CA group in his use of the *–ed* ending.

AB, MD, and MB spelled the endings of irregular verbs and one-morpheme words more accurately than the SA-RA group; they performed similarly to the CA group. Conversely, JG predominantly used the *–ed* ending on irregular verbs and one-morpheme words. As such, his spelling deviated from that of both SA-RA and CA controls.

These data show that while AB, MD, and MB did not use the *–ed* ending very often, JG used this ending most of the time on /d/ and /t/ sound ending words, regardless of word class.

Midway. AB, MB, and MD's spelling of the endings of all three word types words was similar to their spellings at the initial point. JG continued to use the *–ed* ending on regular verbs, and irregular verbs, though on one-morpheme words he used the phonetic and *–ed* endings equivalently.

Final. AB and MB continued to under-use the *–ed* ending on regular verbs endings, though MB had learned to spell four words (*kissed, turned, killed* and *dressed*). MD's use of the –*ed* ending improved and he used it equivalently with a phonetic ending on regular past tense verbs, and more frequently on irregular verbs (3/10) and one-morpheme words (3/10). Interestingly, by the end of the study, JG had completely changed his spelling strategy; he predominantly used a phonetic ending on all three word types.

Passage dictation of regular and irregular verbs – midway assessment

One week after the midway single word assessment, the children were given the regular and irregular verbs in a passage dictation format.

It has been suggested that dyslexic children are more likely to make errors on inflectional endings in free writing (Carlisle, 1989; Johnson & Grant, 1989). This is because the additional burden of thinking about what to write reduces the allocation of processing available for spelling. One problem with giving children free writing tasks is that they are likely to circumvent their problems with morphological spelling by using irregular past tense forms (e.g., *went* instead of *walked*). To ensure that children did use regular past tense verbs, a passage dictation task was devised using the regular and irregular past tense words from spelling List B.

The purpose of the task was to see if the children made more errors on endings when processing demands were higher. The additional processing demands of this task involved memorising the sentences prior to writing them. The passage was dictated to the children individually, sentence by sentence. The sentences were repeated upon request.

Results

The passage used, and a transcript of the children's writings can be found in Appendix L. The endings the children used on the words in the passage dictation are shown in Table 5.3.

Table 5.3. Spelling of endings on regular past tense verbs and irregular past tense verbs on the passage dictation task.

	AB	MD	MB	JG
Regular past tense				
-ed ending	3	2	2	3
Phonetic ending	5	8	8	7
Omissions	2	0	0	0
Other	0	0	0	0
Irregular past tense				
Phonetic ending	9	10	8	8
-ed ending	0	0	1	2
Omissions	0	0	0	0
Other	1	0	1	0

For AB, MD, and MB, the difference between their use of the correct endings on regular and irregular past tense verbs in the single word task (mid-way point), and the passage dictation task was generally slight. This indicated that the additional processing involved in sentence dictation did not markedly affect their spelling.

The most striking difference occurred for JG, whose scores appeared to be the reverse of those found in single word spelling. In the single word task, he used the *–ed* ending 90% of the time for regular verbs, but only 30% of the time in passage dictation.

For irregular past tense verbs, he used *–ed* endings 80% of the time on the single word task, but only 20% of the time on the passage dictation. Only a week elapsed between the presentation of the passage and the midway single word spelling task. While it is possible that JG's spelling strategy changed within the space of a week, it seems unlikely. A more probable explanation is that in single word spelling, JG applies an apparently morphological rule (and over-applies it to irregular verbs and one-morpheme words) but when additional processing demands are high, he uses a strategy of predominantly phonetic spelling.

One-morpheme and regularly inflected past tense verbs (List A)

In the initial screening phase, the children were given a list of 26 one-morpheme and regularly inflected past tense verbs, 13 per category, to spell. The words were taken from Treiman and Cassar (1996), and were the same list as those used in Experiment 1 (List A), with 4 words removed (because these words appeared on List B). The purpose of giving these words to the children was to see if the pattern of spelling displayed on List B was replicated.

Procedure

As in Experiment 1.

Coding

The spellings were coded in the same way as List B.

Controls

Control data for both SA-RA are CA controls are taken from Experiment 1.

Results

A list of the children's spellings can be found in Appendix M. The accuracy of their spellings is shown in Table 5.4.

Table 5.4. Accuracy at spelling the ending of one-morpheme words and regularly inflected past tense verbs

	SA-RA	CA	AB	MD	MB	JG
One-morpheme (max = 13)						
Phonetic ending	7.67 (2.9)	11.32 (1.87)	12	12	13	**4**
-ed ending	0.46 (0.99)	0.17 (0.47)	**1**	0	0	**9**
omissions	2.64 (2.7)	0 (0)	0	0	0	0
other	0.75 (1.17)	0.28 (0.59)	0	1	0	0
Regular past tense (max = 13)						
-ed ending	5.85 (3.9)	12.07 (1.2)	**2**	**2**	**2**	10
Phonetic ending	4.28 (2.56)	0.78 (0.18)	**11**	**9**	**11**	**3**
omissions	0.003 (0.18)	0 (0)	0	**2**	0	0
other	0.96 (1.6)	0.007 (0.26)	0	0	0	0

Note: standard deviations in parentheses. Blue font indicates scores outside 1.65 S.D. of CA mean; red font indicates scores outside 1.65 S.D. of SA-RA mean.

These data replicate those shown in Table 5.2. AB, MD, and MB were all age appropriate on their spelling of the ending of one-morpheme words, but they performed at the level of the SA-RA children on the regular past tense verbs. JG used the *–ed* ending on regular past tense verbs less than CA controls, and he over-used the *–ed* ending on one-morpheme words, and so deviated from both control groups.

Omission of inflections

It has been suggested that dyslexic children have a tendency to omit inflectional endings in spelling, though there is no convincing data to suggest that this occurs more on inflected past tense verbs than on one-morpheme words.

The number of final consonant omissions made on regular past tense verbs and one-morpheme words was calculated by adding the number of omissions on regularly inflected /d/ and /t/ verbs and one-morpheme words (initial assessment, N=10 per category) and one and regular past tense verbs (Treiman's list, n=13 per category). These data are shown in Table 5.5.

Table 5.5. Number of final consonant omissions on one morpheme words and regular past tense verbs (max = 23)

	AB	MD	MB	JG
One-morpheme	0	0	0	0
Regular past tense	1	5	0	0

MD made more omissions on regular past tense verbs compared to one-morpheme words and AB made only one omission. This could indicate that these two children decomposed the words at the morphemic level prior to spelling them, which the other children did not.

Reading of morphologically complex words

The children were given one-morpheme and regularly inflected past tense verbs from List A in Experiment 1 to read (adapted from Treiman & Cassar, 1996). The task was administered two weeks after the children had been asked to spell these words. The aim was to investigate whether they had particular difficulty reading regular past tense verbs compared to one-morpheme words.

Procedure

The words were randomised and presented on A4 paper, 3 words per line (Arial 22 font). As both sets of words were presented together, it was not possible to gain timings for each set of words.

Controls

Control data was provided by the SA-RA and CA groups from Experiment 1.

Results

The children's reading errors are shown in Appendix N. The results are shown in Table 5.6.

Table 5.6. Number of one-morpheme and regular past tense verbs correctly read by children

	SA-RA	CA	AB	MD	MB	JG
One-morpheme Max = 16	10.1 (5)	15.35 (1)	**11**	**9**	**11**	**11**
Regular past tense Max = 16	9.28 (4.38)	15 (1.6)	**11**	**8**	**4**	**12**

Note: standard deviations in parentheses. Blue font indicates scores > 1.65 S.D. of CA mean; red font indicates scores > 1.65 S.D. of SA-RA mean.

With the exception of MB, none of the children were worse on regular past tense verbs compared to one-morpheme words. An examination of MB's errors on regular past tense verbs showed he did not omit any inflectional endings; they tended to be whole word substitution errors (e.g., *killed* > *called*; *raked* > *racked*; *shared* > *shard*).

All children were impaired on both one-morpheme words and regular past tense verbs relative to CA controls, but they were all within the S.D. = 1.65 limit for the SA-RA group.

Suffixed and pseudo-suffixed words

The children were given a list of suffixed (e.g., *rusty, painter*) and pseudo-suffixed (e.g., *liver, fairy*) words, which were matched for length and frequency (Funnell, 1987). The purpose of this task was to see whether MB's problem with regular past tense verbs, relative to one-morpheme words, was due to morphological difficulties (i.e., problems assembling morphemes) or due to the nature of the ending of words (i.e., they look like suffixes).

Procedure

The words were randomised and presented in two lists of 32 words each (A4 paper, Arial 22 point).

Controls

There was no control data for this task.

Results

The results are shown in Table 5.7.

Table 5.7. Number of words correctly read on suffixed and pseudo-suffixed words

	AB	MD	MB	JG
Pseudosuffixed (max = 32)	23	13	20	20
Suffixed (max = 32)	26	23	21	19

AB, MB, and JG performed equivalently on the suffixed words compared to the pseudo-suffixed words, whereas MD was much better on suffixed words. This suggests none of the children had inherent difficulties reading two-morpheme words relative to one-morpheme words.

Conclusions about the processing of regularly inflected verbs in written language

In spelling, AB, MD, and MB, were all impaired in their use of the *–ed* ending on regular past tense verbs, yet were within the normal range of CA controls on irregular past tense verbs and one-morpheme words. Over the period of the study, AB and MD's use of the *–ed* ending did not improve to any great extent. MB also remained impaired at using the *–ed* ending on regular past tense verbs throughout the study, but over time he showed more of a progression towards normal developmental patterns than either AB or MD. By the end of the study, he used the *–ed* ending 50% of the time on regular past tense verbs, and his over-generalisation of this ending to irregular verbs and one-morpheme words increased.

JG differed from the outset from the other children. For the first half of the study, he applied the *–ed* ending to regular verbs, irregular verbs, and one-morpheme words for both /d/ and /t/, sound ending words. This suggested that he either had knowledge of the *–ed* ending and was over-generalising it to an exaggerated extent, or that he had learned the *–ed* ending and simply used it indiscriminately. The latter option is the most likely, because if he had been using a morphological strategy, he should have reduced the number of over-generalisations to one-morpheme words by the end of study. Instead, he completely changed his spelling strategy to a phonological one; his spellings on List B at the end of the study closely resembled those of the other children at the start of the study.

In reading, AB, MD, and JG were not impaired in reading morphologically complex words in relation to one-morpheme words, or suffixed words in relation to pseudo-suffixed words. Although below the normal range for CA matched controls on one-morpheme words and regular past tense verbs, they were similar to SA-RA controls in their reading of these words.

MB appeared to be poorer at reading regular past tense verbs compared to one morpheme words, but his errors, which were visual, and his equivalent performance on the suffixed and pseudo-suffixed list, suggested that he did not have a fundamental problem with reading two morpheme words compared to one-morpheme words

LEXICAL VS. SUB-LEXICAL READING AND SPELLING

In Chapter 1, the dual route model of spelling and reading was outlined. The lexical route involves a look-up procedure in which presented words activate stored lexical representations. This route is used for reading and spelling both regular and irregular words. Conversely, non-words are processed sub-lexically, through the application of phoneme-grapheme rules. Regular words, which have common grapheme-phoneme sequences, can be read or spelled using either of these two routes, so if access to a lexical representation for a regular words fails, it may be read and spelled through adoption of a 'sounding out' strategy. Because two strategies are available, children tend to be better at reading and spelling regular words compared to irregular words.

Children's performance on irregular and non-words are often used to assess the relative functioning of these two reading and spelling routes (e.g., Baddeley, Ellis, Miles, & Lewis, 1982; Castles & Coltheart, 1993; Coltheart et al., 1983; Temple & Marshall, 1983).

In this study, the children's lexical and sub-lexical routes were assessed for both spelling and reading. In Experiment 3, regression analysis showed that orthographic knowledge (measured by number of silent letters represented in irregular spelling + accuracy at irregular word reading) emerged as the only predictor of all children's use of the *–ed* ending (though for the SA-RA group, morphological awareness also emerged as a predictor). On the basis of this finding, it was expected that the four children in this study would be impaired in irregular word reading and spelling.

Lexical and sub-lexical spelling

The test comprised regular and irregular words, and non-words. There were 20 items in each category. The regular words and non-words were matched for number of phonemes. All three lists were matched on number of letters, and the regular and irregular words were matched for frequency (Carroll et al., 1971). A list of the words can be found in Appendix O.

Procedure

Words were dictated to children as single words. They were asked to attempt to spell all words, even if they did not know them. Children wrote their responses in spelling booklets, one word per side.

Controls

CA control data (n = 21) for this task was provided from Tainturier et al. (unpub).

Coding

The real word spellings for the dyslexic and control children were coded as orthographically correct or incorrect. Non-words were marked correct if they were a phonologically plausible representation of the spoken version. An indication of the spelling strategies used by the children was gained by coding the dyslexic children's errors on real words as phonologically plausible. They were considered plausible if, when read aloud, they sounded like the target word.

Results

A list of the children's spellings can be found in Appendix P. Their results are shown in Table 5.8.

Table 5.8. The number of correct spellings on regular, irregular, and non-words and the percentage of phonologically plausible errors on regular and irregular words

	CA	AB	MD	MB	JG
Regular words (max = 20)	17.57 (2.27)	**12**	**11**	**7**	**12**
% phonologically plausible errors		12.5	0	0	75
Irregular words (max = 20)	10.85 (3.6)	**1**	**2**	**2**	**1**
% phonologically plausible errors		36.8	27.8	44.4	73.6
Non-words (max = 20)	14.04 (4.5)	8	8	10	14

Note: Standard deviations in parentheses. Blue font indicates scores > 1.65 S.D. of CA mean

All children were impaired on regular word and irregular word spelling. On non-words, the variance was high for normal children, so the dyslexic children were all in the normal range for the CA group. However, whereas JG's non-word spelling score was very similar to the CA mean, AB, MD and MB's scores were well below the CA mean.

In order to check that MB's, MD's and AB's lack of impairment on non-words was not an artefact of high variability in the CA group, the children were given the 16 non-words from Experiment 2, and their scores on this task were compared to the CA group from Experiment 1 (n= 28). The CA mean on non-words was 13.07, the S.D. was 2.5, and the range was 8-16. AB, MD, MB, and JG scored 9/16, 10/16, 10/16, and 13/16 respectively. All these scores were within 1.65 S.D. of the CA mean. This confirms that AB, MD and MB were not impaired in non-word spelling relative to children of the same age, contrary to what is found in general dyslexic populations (Bruck, 1988). Nevertheless, the types of errors they made on real words suggests that AB, MB, and MD have poor sub-lexical skills compared to JG; more than half their spelling errors were not phonologically plausible, whereas the majority of JG's errors were phonetically plausible.

All the children were markedly more impaired on irregular word spelling in relation to their spelling on regular words and non-words, indicating that all the children have poor lexical representations.

Lexical and sub-lexical reading

The children read the words from the spelling study described above two weeks after they had been asked to spell them. The words were presented in three lists: regular words, irregular words, and non-words.

Procedure

The words were presented on A4 paper in list format (Arial 22 font). The children were asked to read down the list of words, and say 'pass' for any they did not know. They were timed from the start of articulating the first word to the end of articulating the last word.

Controls

Control data for this task comes control group 2 (n = 21).

Results

The results are shown in Table 5.9.

Table 5.9. Reading accuracy and latencies for regular words, irregular words, and non-words

	Controls	AB	MD	MB	JG
Regular words (max = 20)	19.7 (0.7)	**14**	**18**	**18**	**17**
Time (secs/words)	0.8 (0.3)	**1.35**	**2.8**	**1.42**	**4.6**
Irregular words (max = 20)	17.14 (2.08)	15	**8**	**8**	**6**
Time (secs/words)	1.16 (0.62)	1.47	**3**	**3.2**	**8.3**
Non-words (max = 20)	16 (4.0)	**5**	**4**	16	16
Time (secs/words)	1.5 (0.58)	**3**	**4.5**	**2.3**	**4.1**

Note: standard deviations in parentheses. Blue font indicates scores > 1.65 S.D. of CA mean

As the CA control group was at ceiling on the regular word reading task, there was very little variance in their scores. All the dyslexic children were impaired on these words in terms of accuracy and time relative to children of the same age. However, MD, MB, and JG had scores that were close to the control mean, so did not *appear* significantly impaired on the regular words, while AB was clearly impaired. On irregular words, MD, MB, and JG were impaired in accuracy and speed, whereas AB was within the normal range for both. On non-words, MD and AB were impaired in accuracy, and all children are impaired on latencies. The data from this task suggest that AB has adequate lexical representations in reading.

Error analysis

A list of each child's reading errors on irregular words are shown in Appendix Q. As the primary focus of this study is spelling, the analysis of reading errors was not detailed, but they did provide some indication of the strategies the children used in reading irregular words. The errors were categorised as visual if they shared some letters of the target word and were real words (e.g., *rhythm* > *rhyme*); regularisation if they were regularisation errors (e.g., *island* > *izland*); and nonsense if the child produced a nonsense word (e.g., *yacht* > *vack*). The results of this analysis are shown in Table 5.10.

Table 5.10. Types of errors made on irregular words (max = 20 words)

	AB	MD	MB	JG
Total errors	5	12	12	14
Visual	1	6	2	2
Nonsense	4	6	7	7
Regularisation	0	0	3	5

The analysis showed that the children employed different strategies in single word reading. Visual errors suggested that children were using a lexical process, and were generating a similar looking word if they could not find a match in their lexicon. When a similar looking word did not exist, they produced a nonsense word. Regularisation errors occurred when a child used a predominantly letter-sound strategy.

AB and MD mostly used a lexical strategy, because they tended to generate similar looking words to the target, and failing that, generated nonsense words. MB and JG used both a lexical and sub-lexical strategy in reading; they produced similar looking real words and nonsense words, and made regularisation errors.

Conclusions about the children's lexical and sub-lexical processing

All the children were impaired in regular and irregular word spelling, but not non-word spelling (though AB, MD, and MB's scores were low on this).

In reading, AB was impaired on regular words and non-words, but not irregular words. MD was impaired in regular, irregular, and non-word reading. MB and JG were impaired on regular words and irregular words, but not non-words. Overall, the children's reading speed was impaired for all types of words, so even though MB and JG's reading of non-words was normal, their slower speeds indicated that their grapheme-phoneme connections were not automatic.

All the children's lexical representations were poorly specified in spelling and reading, with the exception of AB, whose irregular word reading was good. Although all children were impaired in regular word reading, their scores were not particularly poor. Regular words can be read by either whole word recognition strategies, or sounding out strategies. Control children may use sounding out to help them read regular words for which they have no lexical representation, and it appears that this strategy was used by MB and JG, both of whom were normal in non-word reading. Conversely, AB and MD's poor non-word reading scores suggested they do not have full access to this auxiliary strategy for reading.

The errors made by AB and MD on real words support the notion that they are both predominantly whole word readers. Their errors tended to be whole word visual substitution errors rather than regularisation errors. Conversely, MB and JG appeared to use a sounding out strategy in reading.

Tentatively, it could be suggested that the group of four might be split into three sub-types. Manis et al. (1996) suggested that a simple way of identifying 'pure' cases of surface and phonological dyslexia is to use cut-off scores based on the mean and standard deviation scores of the CA group's scores. The use of a cut-off score of 1.65 standard deviations in this study is more stringent than the level of 1 S.D. used in Manis et al.'s study. Using the 1.65 S.D. deviation measure, it was found that AB was impaired on non-word reading, but not on irregular word reading, which is a consistent with a phonological dyslexic profile. Conversely, MD and JG were impaired in irregular word reading, but not non-word reading, which is consistent with a surface dyslexic profile. MB was impaired in both non-word and irregular word reading, so presents a mixed profile.

ORTHOGRAPHIC KNOWLEDGE

Orthographic choice tasks involve asking children to judge the correctness of one of two spelling alternatives. This process assesses the functioning of lexical processes, specifically the orthographic input lexicon.

Many studies have concluded that orthographic skills are parasitic upon phonological processing abilities, because decoding skills facilitate reading, which in turn lead to the construction of the orthographic lexicon (see Share, 1995, for a discussion). However, other studies have shown that even after variance associated with phonological processing has been partialled out, orthographic processing skills explain significant variance in reading and spelling ability (Barker, Torgesen & Wagner, 1992; Cunningham & Stanovich, 1990, 1993; Stanovich & West, 1989).

All children in this study were impaired in irregular word spelling and reading (except AB, whose irregular word reading was relatively good), and the orthographic choice tasks were used to test the extent of their poor lexical representations.

Letter string

This task was taken from Cunningham, Perry, & Stanovich (2001), which they adapted from the work of Treiman (1993; Cassar & Treiman, 1997). It assesses children's awareness of common orthographic sequences, because they have to decide which of two non-words is more word-like.

Stimuli

The 16 paired items of three to seven letter strings were: beff-ffeb, ddaled-dalled, yikk-yinn, vadding-vayying, nuck-ckun, ckader-dacker, vadd-vaad, muun-munt, ist-iit, moyi-moil, aut-awt, bey-bei, dau-daw, gri-gry, chim-chym, and yb-ib. The split-half reliability (Spearman-Brown corrected) was 0.51 (Cunningham et al., 2001).

Procedure

The sixteen pairs were presented side by side on a piece of A4 paper (Arial, 22 point). The children were tested individually and told, "Place a blank piece of paper under row number one. You should see two nonsense word pairs (experimenter pointed to *beff* and *ffeb*). I'd like you to circle the one that looks most like it could be a real word. If you don't know the answer, just guess."

Orthographic choice 1 (OT1) (regular words)

This task was taken from Cunningham, Perry, & Stanovich (2001), who adapted it from Olson and colleagues (e.g., Olsen, Forsberg, Wise, & Rack, 1994; Olson, Wise, Conners, Rack & Fulker, 1989).

Stimuli

There were 23 paired items, each containing a word and non-word homophone. Selection of the correct spelling involved using a lexical look-up procedure. The items were: take-taik, gote-goat, sleap-sleep, hole-hoal, rume-room, snoe-snow, face-fase, hert-hurt, sheep-sheap, smoak-smoke, bowl-boal, cloun-clown, word-wurd, cote-coat, rain-rane, stoar-store, lurn-learn, nice-nise, scair-scare, skate-skait, true-trew, streem-stream, and wise-wize. The split-half reliability (Spearman-Brown corrected) was 0.84 (Cunningham et al., 2001).

Procedure

The pairs were presented side by side on a piece of A4 paper (Arial, 22 point). Children were asked to place a piece of paper under each row and circle the item that was spelled correctly.

Orthographic choice 2 (OT2) (Irregular words)

This task was developed by using the 20 irregular words from the reading and spelling task. A 'regular' spelling was taken from the children's own spelling errors. The purpose of the task was to assess the extent to which the children's difficulties with irregular word spelling was due to problems at the level of orthographic output, or due to faulty lexical representations in the orthographic input lexicon. There are limitations to this task, because only one of each set, notably the incorrect spelling, produces a word-like phonological representation. Therefore children who rely heavily on the sub-lexical route are likely to choose the incorrect spelling because it sounds like a real word. To counter this, children were instructed to use a visual strategy.

Stimuli

The 20 paired items were: foren-foreign, wulf-wolf, oshun-ocean, parm-palm, regime-raysheme, sugar-shugar, surfis-surface, iron-one, bowkay-bouquay, cough-coff, iland-island, echo-ecow, meringue-marang- whisper-wisper, rhythm-rithim, silens-silence, gost-ghost, furious-fureous, sword-sord. These words were randomly interspersed with the items from the regular, irregular, and non-verb orthographic choice task outlined below.

Procedure

The children had to circle the correct spelling. In order to prevent them from using a sub-lexical route in this task, which may have caused them to make many errors, they were asked to just look at the words and make a judgement as quickly as possible as to which looked like the correct spelling. They were warned that some of the words may be ones they could not read, but they were told to make a guess.

Regular verbs, irregular verbs, and one-morpheme words

The purpose of this task was similar to that of the irregular word orthographic choice task, but the focus was on how well children knew which words were spelled with an *–ed* ending. As both spellings on this task generated the same sounding word when read sub-lexically, children had to use lexical look-up processes to perform the task correctly.

There were 15 regular past-tense verbs (10 were taken from the spelling task from Experiment 1 that was based on the Nunes et al. (1997a) task and 5 were from the Treiman and Cassar (1996) spelling task). These were paired with a phonetic spelling, some of which were generated from the children's own spelling errors. In addition, there were 10 irregular verbs and 10 one-morpheme words (taken from the spelling task from Experiment

1 that was based on the Nunes et al. (1997a). A spelling using an over-generalisation of the *–ed* ending was created from some of the children's own spelling errors.

Stimuli

The regular past tense pairs were: covered-coverd, turned-turnd, slipped-slipt, kicked-kickt, kild-killed, cald-called, dressed-drest, stopped-stopt, kissed-kist, laft-laughed, filled-fild, puffed-puft, leaned-leand, racked-raikt, and raced-raste. The irregular past tense pairs were: heard-heared, left-lefed, sleeped-slept, losed-lost, sent-sened, founed-found, sold-soled, heled-held, toled-told, and felt-feled. The non-verb pairs were: soft-sofed, brand-braned, except-exceped, child-chiled, blind-blined, coled-cold, thired-third, wiled-wild, wrist-wrised, and friend-friened.

Procedure

The paired items were presented with the irregular word orthographic choice task, and so children received the instruction to complete this task as quickly as possible and to make judgements based on the look of a word.

Results

In order to assess whether the children were guessing, a series of chi-square tests were carried out on each child for each task. On Table 5.11, bold print indicates where children performed at chance level. ($p = 0.05$). It can be seen that JG performed at chance on all the tasks.

Table 5.11. Number correct on the orthographic awareness tasks

	AB	MD	MB	JG
Letter string (max = 16) e.g., ffeb-febb	**13**	14	14	**13**
OT1 (max = 23) e.g., rake-raik	22	20	20	**16**
OT2 (max = 20) e.g., foren-foriegn	**14**	**14**	**13**	**14**
Regular verb (max = 15) e.g., covered-coverd	14	**12**	**4**	**6**
Irregular verb (max = 10) e.g., left-lefed	**8**	**7**	**5**	**5**
Non-verb (max = 10) e.g., cold-coled	9	**8**	9	**6**

Note: Scores that do not differ from chance are denoted in bold

PHONOLOGICAL AWARENESS

Phonological awareness is a portmanteau term for a range of capabilities that involve tapping into phonological processing at some level (see Ramus, 2001). Digit span and non-word repetition are verbal short-term memory tasks that involve sustaining phonological representations for a short period of time. Whereas digit span can be memorised using both sub-lexical and lexical processes, non-word repetition only uses the sub-lexical level.

Meta-phonological tasks vary considerably, and include phoneme deletion, alliteration tasks, and spoonerisms (Yopp, 1988). Ramus (2001) suggests that central to such tasks is sub-lexical phonological representation (as this is the only level when phonemes and rimes can be represented as such) and the capacity to consciously pay attention to and manipulate these phonological units. Children may be impaired in either one or both types of phonological tasks (phonological memory and meta-phonological). Deficiencies in either domain can underpin difficulties in reading and spelling processes. In this study, children were administered both types of tasks.

PhAB

The children were administered 5 sub-tests of the Phonological Assessment Battery (PhaB) (Frederickson, Frith, & Reason, 1997). This standardised test has norms up to the age of 14 years. In addition, the 21 CA children from Tainturier et al. (unpublished) provided control data. The results are shown in Table 5.12.

Table 5.12. Standardised scores on sub-tests of the PhAB

	CA controls	AB	MD	MB	JG
Alliteration	99.61 (1.74)	100	100	100	100
Spoonerisms	114.85 (12.13)	101	90	106	123
Fluency (alliteration)	106.47 (10.87)	99	104	**86**	120
Fluency (rhyme)	107.28 (11.13)	111	92	96	107
Semantic	110.28 (16.6)	118	**79**	102	120

Note: standard deviations in parentheses. Blue font indicates scores outside 1.65 S.D. of the CA mean

On the PhAB, a child is impaired if their standardised score falls below 85. Using this criterion, only MD was impaired, and this was on a non-phonological semantic task (i.e., generating as many words in a category as possible). The results suggest that none of the children had phonological deficits, but this is based on a mean standard score of 100. This was not the case with the control sample, most of whom scored over 100. Using the 1.65 S.D. outside of the CA mean criterion, MB was impaired on the alliteration fluency task and JG was clearly normal on phonological skills.

Experimental tests of phonological awareness

The children were administered the phonological tasks used in Experiment 3 – non-word repetition, phoneme deletion, and digit span. The procedures were the same as those in Experiment 3, and both SA-RA and CA control data were provided by the children from Experiments 1-5. The results are shown in Table 5.13.

Table 5.13. Children's scores on experimental tasks of phonological awareness

	SA-RA	CA	AB	MD	MB	JG
Phoneme deletion (max = 12)	6.03 (2.7)	9.42 (2.04)	8	**4**	**4**	9
Non-word repetition, no. syllables (max = 54)	27 (13.31)	35.42 (11.9)	**14**	25	25	48
Digit span	5.2 (1.11)	6 (1.3)	5	4	6	6

Note: Standard deviations in parentheses. Blue font indicates scores > 1.65 S.D. of CA mean; red font indicates scores > 1.65 S.D. of SA-RA mean.

AB and JG were within 1.65 S.D. of the CA group mean on phoneme deletion, whereas MD and MB were impaired. On non-word repetition, MD, MB, and JG performed within 1.65 S.D. of the CA group, but AB was very impaired, scoring below – 2 S.D.s of the CA group. All children had digit spans within the normal range. None of the children were deficient relative to SA-RA controls.

Conclusions from phonological tasks

Overall, the children were not deficient in phonological awareness. However, AB was very poor on non-word repetition, and MD and MB were impaired on phoneme deletion. The interesting result here was that JG appeared to have no phonological impairments, as he performed similarly to children of the same age on all tasks.

GRAMMATICAL AWARENESS

Difficulties with grammatical awareness in spoken language could plausibly underpin poor use of the *–ed* ending in spelling regular past tense verbs. It has been suggested that morphological awareness enables children to over-ride their tendency to use phonetic endings in spelling (Nunes et al., 1997a).

Grammatical Tasks

The children were given the three grammatical awareness tasks from Experiment 3 and the administration procedure was the same as in Experiment 3. In addition, they were given further tasks:

Test for Reception of Grammar (TROG)

This is a standardised test for children up to 12 years of age, and was developed by Bishop (1983) to assess understanding of grammatical contrasts in English. The test comprises 80 sets of four pictures, and the child has to chose which picture best describes a sentence read out by the tester.

Word analogy

This task was developed by Nunes et al. (1997a). It involves providing children with two words (e.g., *anger-angry*) and then providing a further word (e.g., *strong*) and asking children to generate a word based on the change that occurred in the first set (i.e., *strength*). This task assesses children's ability to generate morphologically related words based on analogy with other words. The full test is shown in Appendix R.

Controls

The control data for this task came from Nunes et al.'s data of children with a mean age of 9 years 7 months (S.D. = 10.3) who could spell the endings of regular past tense verbs correctly (these are equivalent to the CA group used in Experiment 1), and children with a mean age of 7 years 9 months (S.D. = 10.1) who had started to use the *–ed* ending in spelling regular verbs but over-generalised this ending to irregular verbs and one-morpheme words (these are equivalent to the SA-RA group used in Experiment 1).

Producing inflections

This task was developed by Marchman, Wulfeck, and Weismer (1999) to assess children's ability to elicit regular and irregular past tense forms. There were 25 regular forms, and 27 irregular forms. Irregular verbs included zero-markings (e.g., *hit>hit*), vowel changes (e.g., *ring>rang*), and blends (e.g., *feel>felt*). The procedure was to show children pictures of an action and ask them to complete a sentence (e.g., *This butcher is cutting meat. He cuts meat everyday. Yesterday, he .....*).

Controls

There was no control data for this task.

Producing and decomposing derivations

This task was developed by Carlisle (2000) to assess children's awareness of the relations of base and derived forms. One part required the decomposition of derived words in order to finish a sentence (e.g., *growth. She wanted her plant to ....*) and the second part required the production of a derived form to finish a sentence (e.g., *warm. He chose the jacket for its .....*). Half the items in each set contained a phonologically transparent change (e.g., *fame>famous*) and half contained a change that involved phonological shift (e.g., *five>fifth*).

Controls

Control data were provided by 34 3rd graders and 26 5th graders taken from Carlisle's (2000) study. These grades are equivalent to Years 4 and 6 in British schools, and so the children were a year older than the SA-RA and CA controls used in Experiment 1.

Results

The children's scores on the grammatical tasks are shown in Table 5.14.

Table 5.14. Children's scores on the grammatical awareness tasks

	SA-RA	CA	AB	MD	MB	JG
TROG (standard score)	-	-	122	114	114	134
Inflecting nonsense words Max = 11	7.7 (3.4)	10.21 (1.57)	11	11	11	11
Morphological judgement Max = 6	4.3 (1.4)	5.6 (0.86)	6	6	**4**	6
Sentence analogy Max = 8	3.5 (2.1)	6.9 (1.2)	6	7	**3**	8
Word analogy Max = 8	2.27 (1.55)	2.57 (1.7)	3	3	3	5
Producing regular inflections Max = 25	-	-	25	25	20	23
Producing irregular inflections (max = 27)	-	-	26	25	25	26
Production – transparent % correct	75.2 (14.6)	88.6 (9)	92.8	85.7	78.5	75.4
Production – shift % correct	38.5 (7.4)	63.1 (10.1)	64.2	50	**42.8**	50
Decomposition – transparent % correct	85.1 (11.6)	96.1 (5.1)	92.8	**78.5**	**85.7**	92.8
Decomposition – shift % correct	79.2 (12.2)	91.7 (10)	78.5	78.5	**58.1**	85.7

Note: Standard deviations in parentheses. Blue font indicates scores > 1.65 S.D. of CA mean; red font indicates scores > 1.65 S.D. of SA-RA mean.

On the Marchman task (producing regular and irregular inflections) for which there were no control data, all children were at or near ceiling. On the other tasks, AB and JG were within the normal range of the CA control group. MB was impaired on morphological judgement and sentence analogy, decomposing derivations that are phonologically transparent, and producing and decomposing derivations that require a phonological shift. On this last task, MB was impaired relative to SA-RA controls on decomposition – shift. MD was impaired compared to the CA group on decomposing transparent derivations.

Conclusions from grammatical awareness tasks

AB, MD, and JG do not have deficits, relative to younger children of the same reading level, in grammatical processing. MB was impaired relative to CA controls on 5/11 tasks, and compared to US children in Grade 3 (UK Year 4) on one task. Three of the tasks on which MB was impaired involved producing morphological relations to targets that differed phonologically from their base form, which could indicate impairments in both phonological and morphological processing. MD performed similarly on opaque and transparent decomposition of derived forms, but unlike normal children of his age, he did not seem to benefit from phonological transparency, and this would be consistent with his phonological impairments.

VISUAL PROCESSING

While many studies show that dyslexic children exhibit deficits in phonological processing compared to younger children matched on orthographic skills (Snowling, 1981; Rack, Snowling, & Olsen, 1992) it appears that this was not the case with the children in this study. None of them were deficient, in relation to younger children of the same reading level, on phonological tasks. Indeed, the children consistently performed at similar levels to their same aged peers on the majority of tasks, the exception being MD and MB, who were impaired on phoneme deletion, and AB who was impaired on non-word repetition. Phonological impairments were more pronounced on non-word reading; AB and MB had poor reading accuracy, and all children were slow at making grapheme-phoneme correspondences.

The children's performance on the irregular and non-word reading tasks showed the children could be divided into three sub-groups: phonological, surface, and mixed. There has been some suggestion that there is an association between visual processing and dyslexia sub-types. Goulandris and Snowling (1991) report the case of JAS, a developmental surface dyslexic with good phonological skills whose deficits were in the domain of visual memory. Studies have also shown that low level visual processing deficits, assessed through sensitivity to contrast, tend to be associated with phonological dyslexia (e.g., Cestnik & Coltheart, 1999), whereas surface dyslexic children exhibit difficulties with visual attentional tasks (Valdois et al., 2003).

The children were given two visual tasks: memory and visual attention (Valdois et al., 2003).

Visual memory

British Ability Scales Test of Recall of Designs

In this test, 19 geometric illustrations have to be drawn from memory following a 5 second study period.

Visual Recognition

Cashman & Van Daal (unpublished) developed this task. The participant is required to study a series of 24 geometric configurations for 5 seconds and then choose the one previously examined from a selection of 4 alternatives. There was no control data for this task.

Results

The results on both these visual memory tasks are shown in Table 5.15

Table 5.15. The children's performance on tasks of visual memory

TASK	AB	MD	MB	JG
Recall of Designs (standard score)	104	98	100	102
Visual recognition (max = 24)	24	24	24	24

The results show that none of the children have impairments in visual memory.

Visual attention

Valdois et al. (2003) developed the visual attention processing tasks. Children have to report strings of 5 rapidly presented letters. Poor performance would indicate that a child has a limited visual attentional 'window'; this would have a deleterious effect on reading because children would be unable to accurately encode all the letters in a word in the correct sequence. Before the main tasks were administered, children performed a letter threshold task to ensure that they could read rapidly presented letters at intervals of 33, 50, 67, 84, and 101 m/secs. AB, MD, and JG scored above chance (46/50, 30/50 and 40/50 respectively) but MB was poor on this (18/50), so his scores on the main tasks should be interpreted with caution.

Controls

Control data is provided from the 21 CA controls used for the irregular word, regular word, and non-word reading and spelling tasks.

Whole report

Stimuli

The stimuli were 20 random 5-letter strings (e.g., RHSDM) built up from 10 consonants (B,P,T,F,L,M,D,S,R,H). Each letter was used 10 times and appeared twice in a given position. They were presented in black upper case type (Geneva 24-point font) on a white background. A distance of 1 cm, to avoid lateral masking, separated each letter from the one nearest to it.

Procedure

At the start of each trial a central fixation point was presented for 1000ms followed by a blank screen for 500ms. A 5-letter string, with no repeated items, was presented for 200 m/sec. The participants' task was to report all letters immediately after they disappeared in the correct order. There were 5 training trials for which they received feedback. No feedback was given in the experimental task. The experimenter inputted the responses.

Partial report

Stimuli

The stimuli were 50 random 5-letter strings built up from the same 10 consonants used in the whole report condition. The letters were presented as in the whole report condition. A probe indicating the letter to be reported was a vertical bar presented for duration of 50 m/sec, 1 cm below the target letter. Each letter was used once in each position.

Procedure

At the start of each trial, a central fixation point was presented for 1000 m/sec followed by a blank screen for 500 m/sec. A 5-letter string, with no repeated items, was then presented at the centre of the display monitor for 200 m/sec. The onset of the bar probe was simultaneous with the offset of the stimulus array. Participants were asked to report only the target indicated by the probe, and the experimenter inputted their response. There were 5 training trials for which they received feedback. No feedback was given in the experimental task. They were instructed to be accurate and no time pressure was applied.

Results

The results of the whole report condition are shown in Table 5.16 and the partial report results are displayed in Table 5.17.

Table 5.16. Number of correct responses on the whole report condition.

Letter position	CA	AB	MD	MB	JG
1	19.7 (0.46)	20	20	19	20
2	19.02 (0.99)	20	20	17	18
3	18.38 (1.2)	**16**	**11**	**15**	18
4	15.23 (3.3)	**7**	9	9	13
5	15.9 (2.8)	**7**	**9**	12	**9**
Total	88.3 (6.7)	**70**	**69**	**72**	78
Whole string	11 (4.7)	3	**2**	**2**	5

Note: standard deviations in parentheses. Blue font indicates scores outside 1.65 S.D. of the CA mean

The results show that both the dyslexic and control children were poorer at reporting the middle and last two letters in the string (i.e., central point and right of central) than the first two letters in the string. However, the decrement was more pronounced for the dyslexic children. On the first two letters, all the dyslexic children were as accurate as controls. For the middle letter (no. 3) AB, MD and MB were impaired, on the penultimate letter (no. 4) AB was impaired, and on the final letter, AB, MD, and JG were impaired. This means that all the dyslexic children were impaired at reading one or more letters in the central or right of centre positions. In addition, AB, MD, and MB performed well below the mean for whole string (i.e., accurately reporting the whole string in the correct sequence).

Table 5.17. Number of correct responses on the partial report condition

Letter position	CA	AB	MD	MB	JG
1	9.3 (0.86)	10	10	10	10
2	8.9 (1.48)	9	9	9	8
3	9.5 (0.5)	10	10	**7**	10
4	8.6 (1.7)	10	9	9	10
5	9.57 (0.59)	**8**	9	10	10
Total	46.04 (3.18)	47	47	45	48

Note: standard deviations in parentheses. Blue font indicates scores outside 1.65 S.D. of the CA mean

All children performed similarly to controls on this task, with the exception of MB, who was poorer on the medial position letter, and AB who was poorer on the final letter. These impairments corresponded to those on the whole report task.

Conclusions from the visual processing tasks

If a child has a visual attention deficit, this should be apparent on both the whole and partial report tasks, although it must be considered that the partial report task is easier than the whole report task, and subject to a ceiling effect. The children in this study were poorer on the whole report task, but only MB and AB were poor on partial report. Consequently, it can be concluded that these two children have visual attention deficits.

On the whole report task, all children had decrements in their naming of letters in central position, and to the right of the central position. In terms of reading, this means they all process, and consequently, encode, the final letters in words more weakly than the initial letters . However, in this study the children did not make more errors on the end of words in reading. In spelling, poorer performance on the final letters in a string cannot be viewed as a direct reason for their poor representation of the *–ed* ending in spelling, because they do not appear to have problems representing the final sounds in one morpheme words. However, it could have an indirect effect as it may interfere with the process of storing the spelling of words.

All the children except JG were poor at accurately naming the letter string in sequence (whole string). However, this task involves translating letters into their spoken form and reciting them. The memory component involved in this task could account for the dyslexic children's poorer performance because, while the children were not impaired in digit span, the conversion of the visual representation of letters into sounds requires additional processing which could reduce the efficiency of working memory functions. This interpretation is consistent with the Cerebellar Deficit Hypothesis of dyslexia (Fawcett & Nicolson, 1990), which postulates that dyslexic children have difficulties concurrently carrying out more than one task.

It was expected, based on the data of Valdois et al. (2003) that JG, who presents a surface dyslexic profile, would have been more impaired than the other children in visual attention. In fact, he was better than the other dyslexic children on both tasks. His only deficiency occurred on the final letter of the whole report condition.

SUMMARY OF RESULTS

Table 5.18 gives a general overview of the main areas in which the children were impaired.

Table 5.18. Summary table of children's impairments relative to CA controls on tasks used throughout the study

Underpinning process	Task	AB	MD	MB	JG
Regular past tense verbs	Reading /t/ and /d/ sound ending words				
	spelling /t/ and /d/ sound ending words	X	X	X	X
Sub-lexical route	Non-word spelling	X			
	Non-word reading	X slow	X slow	slow	slow
Lexical route	Irregular word spelling	X	X	X	X
	Irregular word reading	X slow	X slow	X slow	X slow
Lexical representations	Orthographic choice			X verbs only	X
Phonological skills	Phonological memory	X			
	Meta-phonology		X	X	
Grammatical skills	Inflectional processing			X	
	Derivational processing		X	X	
Visual memory					
Visual attention	Whole report	X	X	X	X
	Partial report	X (final letter)		X (central letter)	

Discussion

From an initial group of twenty dyslexic children, three (15%) were selected for further study due to their poor spelling of regular past tense verb endings compared to their good spelling of one-morpheme word endings. This ratio of 15% corresponded to that found in Experiment 5, in which 4/28 (14.28%) dyslexic children demonstrated a similar spelling profile.

In addition to the three children who under-used the *–ed* ending, JG was recruited because of his unusual over-use of the *–ed* ending.

The aim of the study was to determine the cause of the children's difficulties with the *–ed* ending. The children were assessed on their reading and spelling of one-morpheme and regular past tense words. At the start of the study, AB, MB, and MD under-used the *–ed* ending on regular verbs, and this trend continued throughout the study, although MD showed some improvement. Unlike the others, JG used the *–ed* ending on most /t/ and /d/ sound ending words, regardless of word class, for half of the study. He then switched to a strategy that was similar to the one used by the other children.

There are a number of processes involved in spelling the *–ed* ending correctly on regular past tense verbs: auditory, phonological, morphological, and orthographic. The children's capabilities on each of these processes will be assessed in order to determine the likely cause of their difficulties with the *–ed* pattern.

Auditory processing

In order to spell the *–ed* ending, the child needs to hear it and appreciate that it has to be represented in writing. All of the children had adequate hearing, though three had auditory discrimination problems: MB and MD had difficulties with f/th distinctions, and JB had a tendency to confuse nasals (m/n). However, they could all hear consonant endings, because they represented these when spelling one-morpheme words, and none of the children made t/d confusion errors.

Phonological processing

Phonological processes are involved in the spelling of all kinds of words. Phonological impairments might specifically affect spelling of the *–ed* ending in a direct way through its low phonological salience, or in an indirect way whereby poor phonological skills limit children's exposure to print, which in turn reduces exposure to inflected forms.

AB, MD, and MB exhibited different types of phonological impairment. AB was particularly impaired in non-word repetition. Repeating non-words involves the sub-lexical route and also has a strong short-term phonological memory component. Weaknesses in either of these areas can account for poor non-word repetition scores. In AB's case, it is difficult to isolate which component was responsible; he had poor sub-lexical processes (as measured through non-word reading and spelling), and although his digit span was normal, digit span can be supported by long-term memory processes. It is likely that AB did have short-term memory impairments, but as his non-verbal abilities were superior, he may have learned to circumvent this relative weakness by using a number of strategies such as visualisation or semantic recoding to encode 'real' stimuli, like words, letters, and digits.

MD and MB were impaired on meta-phonological tasks, notably phoneme deletion. The ability to delete phonemes develops as a result of reading experience (e.g., Morais et al., 1979). It is likely that these two children's phonological difficulties were more widespread than was indicated by the tasks used in this study; both of the children had auditory discrimination problems (notably f/th confusion). In addition, MB had problems with derivational tasks that involved a phonological shift between one form and another (e.g., *five>fifth*). He was also poor on sentence analogy, and 4/5 of the items on which he failed involved making changes with phonological shifts (*see-saw; was-am; ran-runs; hung-hangs*). In all cases, his responses were regularisations (*see-ed; wasn't; runned; hanged*). It could be that some of his poor performance on morphological tasks was due to the processing demands of performing tasks with both a morphological and phonological component.

While none of the children were deficient in phonological processing, they could have been deficient at an earlier point in time.

The only accurate previous assessment scores that existed were for JG, who was diagnosed dyslexic at age 7 years 9 months. His assessment by an Educational Psychologist at that time showed 'weakness in Gathercole's non-word repetition test suggesting inefficient phonological working memory'. When tested on the non-word repetition task in this study, which was based on Gathercole et al.'s (1994) task but was made harder by combining non-words to produce longer strings, JG performed very well. It seems highly likely, then, that the other children in this study, who were worse on phonological tasks than JG, had even more profound phonological problems than him at an earlier point. This would have affected their initial acquisition of phoneme-grapheme correspondences. Perhaps more complex, psycho-physical assessments of phonological processing would have revealed deficiencies in the children's phonological processing capabilities.

Despite the difficulties with phonology outlined above, it was clear that all the children's phonological skills were sufficient to hear the ending of a word and to represent endings accurately. Therefore, their difficulties with the *–ed* ending could not be due to phonological weaknesses, at least not entirely.

Morphological processes

The third process involved in spelling the *–ed* ending involves over-riding the tendency to use direct phoneme-grapheme correspondences (i.e., *-t, -d, or –ed*), and to instead use a morphological spelling pattern (*-ed*). Nunes et al. (1997a) suggested that the impetus for this process involves two factors: the awareness of the rules involved in inflecting verbs into the past tense form, and the ability to apply these rules to spelling.

In this study, all of the children except MB showed age appropriate awareness of rules relating to inflectional morphology in spoken language. As was discussed earlier, most of MB's difficulties with morphology could be attributed to difficulties with the additional phonological processing demands of tasks rather than problems with morphology. Indeed, Shankweiler et al. (1995) have reported that apparent syntactic difficulties found in children with dyslexia disappear when the processing demands of tasks are reduced. However, MB did perform poorly on morphological tasks when phonological processing demands were low, notably derivational decomposition with no shift (e.g., *variable* > *vary*), and morphological judgement (e.g., *is there a smaller word in kissed that means something like kissed*?). This shows MB had poor awareness of morphology for his age, but he was not deficient in relation to younger children of the same reading age. Consequently, it is difficult to see how his impairments in morphology caused him to be poorer at spelling the *–ed* ending than children with similar levels of reading, spelling, and morphological awareness.

MD was also impaired on derivational decomposition with no shift. As he performed well on other tasks of morphology, it is unlikely that his poor score on this task reflected general difficulties with morphology. He did have difficulties with producing semantically related words on the PhAB, and as morphologically related words are also semantically related, this general word-finding problem could account for his problems with decomposing derivations.

Consequently, it is unlikely that poor knowledge of morphology underpinned low use of the *–ed* ending on regular past tense verbs for any of the children.

Did their difficulty lie in applying morphological knowledge to spelling? The application of rules is difficult to assess, except through nonsense word tasks. In Experiment 4, a task devised to assess rule use revealed that even normally developing children do not use rules in spelling.

Orthographic knowledge

In Experiment 3, it was found that orthographic knowledge had an effect on the spelling of the *–ed* ending for all children. In the multiple case study, the children varied in their orthographic skills. All children were impaired on irregular word reading and spelling, which would indicate that their lexical representations were impoverished. However, AB and MD were good on tasks of orthographic choice. In terms of adult models of lexical processing, this could be interpreted as suggesting that these children's difficulties with irregular words were due to poor *connections* between orthographic and phonological lexicons, rather than poor lexical representations per se. However, Bishop (1997) warns against using adult models to interpret children's lexical and sub-lexical processes. This is because children's systems are developing and changing, so discussions about functions being intact or impaired are erroneous. Intuitively, it seems unlikely that AB and MD had well represented lexical items. Weak lexical representations are inevitable in dyslexic children, because their poor decoding skills in the initial stages of reading development reduce their access to print, which in turn reduces their exposure to irregular words. Unless a child learns to read in a purely logographic fashion, which is highly unlikely given the emphasis placed on decoding in the National Literacy Strategy, a dyslexic child cannot accumulate accurate lexical representations.

So how can AB and MD's poor irregular word reading and spelling be reconciled with their good performance on the orthographic choice tasks? Such tasks give children two spelling options, one of which is correct. In order to make a judgement, the child does not need to have a complete representation of these words in their lexicon. They could carry out the tasks by identifying certain features of words, as well as by using knowledge of the most common spelling patterns in English. For instance, on *rake-raik*, knowledge that the /eɪk/ sound in the rime position is usually spelled *–ake* would be enough to make a correct decision on this item pair. Consequently, it is likely that AB and MD's lexical representations were poor, but that they were good at applying knowledge of the most commonly used spelling patterns when making orthographic choice decisions.

MB was impaired on the orthographic choice tasks for regular verb and irregular verb pairs, and JG was at chance on all of the orthographic choice measures. These data show that MB and JG had very poor lexical representations. In addition, they had weak knowledge of orthographic conventions because they did not, like AB and MD, use this knowledge to make selections on orthographic choice tasks. JG was particularly impaired, relative to the other children, on orthographic choice, and this might account for why his use of the *–ed* ending was apparently erratic over time, in that initially he over-used the ending and then stopped using it.

The discrepancy between the children's non-word spelling compared to their irregular word spelling can certainly account for the discrepancy between their use of the correct ending on regular past tense verbs. Due to factors such as tuition, the dyslexic children in this study had developed phoneme-grapheme skills within the normal range (though it has to be borne in mind that, with the exception of JG, their scores were at the low end of this range). This meant that they were accurate at representing the endings of words phonologically. However, all the children had poor lexical representations, so when the orthographic ending used could be one of two (i.e., a phonetic and morphological one), the children's lexical representations were not accurate enough to enable them to use the correct ending.

In conclusion, it would appear that around 15% of dyslexic children have specific problems with spelling the *–ed* ending. These children do not demonstrate deficits in morphological or phonological awareness, though some of them are impaired in these domains. However, their impairments are not sufficient to account for their poor use of the *–ed* ending. What these children do have in common is a discrepancy between phoneme-grapheme spelling skills and irregular word spelling skills. Consequently, after more extensive testing, it appears that the conclusions made at the end of Experiment 5 still hold: The accuracy of children's orthographic representations at the level of orthographic output primarily underpin their use of the *–ed* ending in spelling. This conclusion fits in with the findings of Experiment 3, which showed that orthographic knowledge had a bigger impact than morphological knowledge on correct use of the *–ed* ending in spelling for dyslexic children.

CHAPTER 6

GENERAL DISCUSSION

The aim of this thesis was to address a number of questions raised by previous researchers regarding the use of inflectional morphology in dyslexic children. Using a design that compared dyslexic children with both chronological and reading and spelling age matched controls, the processing of inflected forms in written language was simultaneously investigated alongside orthographic knowledge, morphological awareness, and phonological awareness.

From the studies carried out, two main issues were addressed: (a) differences between groups on the reading and spelling of inflected forms, and (b) the role of phonological, orthographic, and morphological skills in the spelling of inflected forms. Each of these will be discussed in turn before the limitations of the investigations and ideas for future research are addressed.

Overall group differences in the spelling and reading of inflected forms

In Experiment 1, dyslexic children were compared to children of the same age and IQ, and younger children with the same reading and spelling levels on their reading and spelling of regularly inflected verbs. The CA group was superior to the other groups in their reading of both one-morpheme words and regularly inflected past tense verbs, and they were also better than these groups at using the *–ed* ending in spelling. In fact, they were practically at ceiling in their use of *–ed* on regular past tense verbs, which confirms previous findings that the *–ed* ending in spelling is consolidated between the ages of 9 and 10 years (Beers &

Beers, 1992; Nunes et al., 1997a). They were better than the other groups because they were older, normally developing spellers.

In relation to the SA-RA group, the dyslexic children were similar in their reading of one-morpheme words and regular past tense verbs. However, in spelling, although they were as accurate as these children on the ending of one-morpheme words, they were considerably worse at using the *–ed* ending on regular past tense verbs. This finding contradicts the data of Bryant et al. (1998), who found their backward readers were similar to a RA group on use of the *–ed* ending. Their results could be because their RA group, matched only on reading age, was better spellers. Treiman (1997) suggested that using a reading age matched design when investigating spelling has some difficulties of interpretation, because dyslexic children matched on reading ability may spell more poorly than normally developing readers of the same level.

The robust nature of the *–ed* spelling deficit found in dyslexic children when compared to a reading and spelling age matched sample has been recently confirmed in a study by Hauerwas & Walker (2003). They compared 11-13 year-old dyslexic children with a spelling and reading age matched group on their spelling of inflected forms in both single word and sentence contexts. They found no difference between groups on the single word task, but on the sentence task the dyslexic children were poorer at representing the *–ed* ending. Their lack of an effect in the single word task is not necessarily at odds with the data from Experiment 1, because the children they tested were two to four years older than the dyslexic children tested in this study. It could be that in older dyslexic children, the tendency to underuse the *–ed* ending only becomes apparent when additional processing demands are placed upon them, as is the case with sentence dictation.

An interesting finding from the present series of investigations is that failure to use the *–ed* ending in spelling is not a specific problem affecting all dyslexic children. The group effect reported in Experiment 1 was influenced by four children who did not use the *–ed* ending very frequently. When they were removed, the overall group differences between the dyslexic and SA-RA group was no longer present.

In this study, use of the *–ed* ending in spelling was assessed in forty-eight dyslexic children (28 from Experiments 1-5, and 20 who were screened for the multiple case studies). Of these, only 8 emerged as having a significant discrepancy between their spelling of the *–ed* ending, and their spelling of one-morpheme word endings. This means that 16-17% of dyslexic children may have specific difficulties with inflectional spelling.

Returning to the main group study, an analysis of the errors showed that the dyslexic group was most likely to spell the *–ed* ending phonetically (i.e., with a *–t* or *–d*). Contrary to the findings of Hauerwas & Walker (2003), Johnson & Grant (1989), and Smith-Lock (1991), their most common error was not omission of the *–ed* ending. Although the dyslexic children in this study did make more omission errors than SA-RA controls, the difference was not significant. This contradicts Hauerwas & Walker's (2003) data; their dyslexic children made significantly more omissions than a SA-RA control group. However, in their study, the dyslexic children's incidence of omission errors in comparison to SA-RA controls was far greater in the sentence condition (17% vs. 1%) than the single word condition (7% vs. 1%). This figure of 7% on the single word condition is lower than the 11.59% of *–ed* omissions that occurred among dyslexic children in Experiment 1 in this study.

In Experiment 1, the children's spelling of inflected verb endings was compared to their spelling of one-morpheme word endings. This comparison has not been made in previous studies on dyslexic children's use of the *–ed* ending, and proved extremely useful, because it showed that dyslexic children made final consonant omission errors on one-morpheme words as often as they did on regularly inflected verbs. Consequently, the omission errors reported by previous researchers cannot be said to constitute 'morphological errors'; rather, they may be the result of a general tendency to leave off final consonant endings. This finding mirrors Funnel's (1987) discovery that many of the morphological errors reportedly made by acquired dyslexics were in fact an artefact of their difficulties with reading particular word endings; when patients' performance on suffixed words (e.g., *angry*) was compared to pseudo-suffixed words (e.g., *fairy*), there was no difference in the numbers of errors made.

When analysing the spelling errors made by the dyslexic children in this study, it was interesting to note that none of them made many morphological errors. Incidences of suffix omission and substitution, which have been reported in reading in some developmental case studies (i.e., Henderson & Shores, 1982) and in the adult literature (Caramazza, Miceli, Silveri, & Laudanna, 1985; Coltheart, Patterson, & Marshall, 1980; Job & Sartori, 1984) were scarce. This suggests that the dyslexic children in this study were not decomposing the inflected verbs or using some kind of processing rule. Instead, it suggests that they were processing inflected verbs as wholes.

The data from the two control groups confirmed previous findings that children follow a developmental pattern in representing the *–ed* ending. The SA-RA group represented the ending phonetically and with *–ed* in equivalent proportions, and over-generalised the *–ed* ending to both irregular verbs and one-morpheme words. The CA group represented the ending with *–ed* most of the time and did not make a high proportion of over-generalisation errors. This is consistent with the literature on morphological spelling development, which shows children represent the *–ed* ending phonologically, then start to use *–ed* and overgeneralise it to one-morpheme and irregular past tense verbs, and finally use the ending exclusively on regular past tense verbs (Nunes et al., 1997a).

However, the dyslexic children did not follow the normal developmental pattern to the extent of the SA-RA group. A qualitative difference emerged between the dyslexic and SA-RA groups in their incidence of generalisations of the *–ed* ending to irregular verbs and one-morpheme words. The dyslexic children were less likely to make these generalisations to either type of word compared to the SA-RA group, which raised the possibility that they were either unaware of the morphological rule of, "if a verb is past tense, and the stem does not undergo phonological shift in the past tense form, then +ed", or that they were aware of the rule but unable to apply it. The question of which possibility was most likely was addressed in Experiments 3 and 4 (see section below).

In summary, the data showed most dyslexic children did not follow the normal developmental sequence in spelling regular past tense verb endings compared to younger children. In addition, the results indicated that around 15% of dyslexic children have a specific problem using the *–ed* ending relative to their spelling of the endings of one-morpheme words.

The role of phonological, orthographic, and morphological skills

In order to locate the source of the dyslexic children's difficulties with inflected verbs in spelling, the influences of orthographic knowledge, phonological awareness, and morphological awareness on the spelling of inflections were examined in Experiments 2 and 3.

The performance of the three groups on the measures themselves showed that the CA group was superior to both the SA-RA and dyslexic groups in their ability to read and spell non-words, regular words, and irregular words. This finding is not surprising, as these children were older, normally developing readers and spellers. Comparisons between the SA-RA and dyslexic groups revealed no differences on any of these word types, and again this was unsurprising given that the groups were matched on reading and spelling of real words.

On the phonological awareness tasks, the CA group was superior to the SA-RA and dyslexic groups, which was to be expected given their age and superior literacy skills. However, there was a wide range of scores in the CA group, and some of this group were quite poor on phonological processing. This could indicate that phonological awareness is not consolidated in some children aged 9-10, yet they develop normal literacy skills despite this.

In comparison to the CA group, the dyslexic children did exhibit impairments on all phonological awareness tasks except digit span, which is in line with previous studies. However, contrary to previous research (e.g., Bruck, 1992; Fawcett & Nicolson, 1995a; Snowling, 1995, 2001; Stanovich & Siegal, 1994), the dyslexic children in the present studies were not deficient on phonological awareness tasks compared to the SA-RA group.

The finding that the dyslexic children in the present studies were not phonologically deficient corresponds to data from Hauerwas and Walker (2003). There are three plausible reasons why no phonological deficit among dyslexic children was found in Experiment 3 and in Hauerwas and Walker's (2003) study. Firstly, the dyslexic children in these studies were matched on reading *and* spelling, rather than reading alone. Perhaps in previous studies that report a phonological deficit in dyslexic children, the reading-age matched controls were better spellers compared to the dyslexics, and may have had superior phonological skills. Secondly, the dyslexics' equivalent performance to the SA-RA group on phonological tasks could have been due to the level of phonological awareness training they had received in class teaching (through the Literacy Hour) and from their specialist support teachers. A third reason could be that the measures used in this study were not sensitive enough to tease out differences between groups. Phonological deficits comprise deficiencies in both the accuracy of phonological representations, and the speed with which they are accessed. Some of the tasks on the PhAB, which was used in the case studies, were timed, and did not reveal differences. However, perhaps if all the tasks used in the entire study had been timed, differences between the groups may have emerged.

On measures of morphological awareness, the CA group was near ceiling on all tasks, which suggests that by the age of 9 and 10, inflectional processing is consolidated. The SA-RA group was poorer than the CA controls on all tasks, and their scores were not near ceiling. In fact, there was considerable variability in this group on inflectional morphological awareness tasks, which would indicate that this knowledge is still developing in some children aged between 6 and 8 years, but consolidated in others. This finding questions the assumption that most children have acquired inflectional morphology in spoken language by the time they begin school (Rice, Wexler, & Cleave, 1995).

The dyslexic group was poorer than the CA controls on two morphological tasks involving real words (morphological judgement and sentence analogy), though similar to them on inflectional processing, which involved applying rules to nonsense words. Their poorer performance on the real word tasks could be due to their poorer vocabulary knowledge, as vocabulary is extended greatly through reading, and the CA children were better readers (Fowler & Liberman, 1995). However, in order to be sure of this, a general measure of all the groups' vocabulary knowledge should have been included, and its omission constitutes a limitation of this research. The only evidence that can be offered on this point comes from the multiple case study, in which the four children were assessed on a standardised test of vocabulary (the BPVS). The child (MB) who had the lowest vocabulary score (SS = 101) was the only one who was poorer than the CA group on inflectional morphology tasks involving real words.

Overall, the finding that the dyslexic children were impaired relative to the CA group on morphological tasks is consistent with previous research (Brittain, 1970; Bryant et al., 1998; Doehring et al., 1981; Joanisse et al., 2000; Vogel, 1983; Wiig et al., 1973; though see Smith-Lock, 1991, for a null result).

The dyslexic children were generally better than the SA-RA children on all three morphological awareness tasks, although the differences were not significant. This finding is consistent with those reported in most previous studies (Bryant et al., 1998; Carlisle, 1987; Elbro, 1989; Joanisse et al., 2000). It does not correspond to the data of Hauerwas & Walker (2003), who found their dyslexic children were poorer than their spelling and reading age matched group on a Berko-type task (1958). The difference between the results reported here compared to those of Hauerwas and Walker (2003) could be attributed to differences between the ages of the dyslexic children used in the studies; their children were older and may have had more profound language difficulties. In addition, their dyslexic children had poorer vocabulary scores than the younger spellers.

Multiple regression was employed to assess the extent to which orthographic knowledge, morphological awareness, and phonological awareness contributed to the variance in the children's spelling of the *–ed* ending. Overall, performance on spelling inflected verbs increased with orthographic skill. The SA-RA group's spelling of the *–ed* partially account for their poor use of the *–ed* ending in some children's spelling, these impairments are not in themselves sufficient explanations for their difficulties. All eight children were poor on orthographic knowledge, so it could be concluded that orthographic knowledge is a very important factor in children's ability to use the *–ed* ending. The importance of orthographic knowledge is also supported by the regression analysis reported in Experiment 3.

The finding that orthographic knowledge is important for spelling the *–ed* ending is not surprising in terms of general theories of spelling developing, because it is one of many spelling patterns that children consolidate during the 'orthographic stage' (Frith, 1985). In normal development, the data favour the view that phonology underpins orthographic knowledge, and that phonology and orthography develop in interaction (Ehri, 1992; Muter & Snowling, 1997; Snowling, 1994; Treiman, 1993). In most dyslexic children, their poor use of the *–ed* ending could be explained as weak orthographic skills caused by poor phonological skills; they are poor at spelling the *–ed* ending, but they are also poor at spelling the ending of one-morpheme words. However, the children reported in this study who had a specific problem with the *–ed* ending, despite no real phonological impediments, could have weak associations between phonology and orthography. It would appear that for them, phonology and orthography develop independently, as has been suggested by dual-route theorists (Barry, 1994).

Limitations of the research and ideas for future studies

On the basis of the studies conducted in this thesis, some questions raised by previous research have been addressed, but a number remain.

The first question concerns the precise type of orthographic knowledge needed for spelling of the *–ed* ending. Orthographic knowledge refers to the quality and accuracy of lexical representations. Many words in English contain spelling patterns that can only be represented accurately by retention of the orthographic features of a word. The *–ed* ending could be considered irregular, but in fact it would be more accurate to describe it as ambiguous. This is because *–ed* is one of several phonologically plausible spellings for the end of regularly inflected /t/ and /d/ sound words (i.e., *-t, -d, ed*). In this study, orthographic knowledge was measured by how well children spelled irregular words, and in these words the irregular segment was exceptional and silent. Knowledge of irregular spelling patterns predicted use of the *–ed* ending, which suggests that the knowledge needed for both types of spelling pattern are underpinned by similar processes. However, they may not be precisely the same type of processes. The ambiguity of the *–ed* ending is similar to the ambiguity that exists on schwa vowel sounds (e.g., the 'e' in the final syllable of *independent* could be an 'a'). In future studies, it would be useful to assess the children's spelling of both irregular (e.g., *wrist, bouquet*) and ambiguous spelling patterns (e.g., *similar, independent*). It could be that the relationship between the *–ed* ending and ambiguous patterns is stronger than that between the *–ed* ending and irregular patterns.

A further area of research that could be developed concerns the extent of dyslexic children's difficulties with inflectional morphology in written language. In these experiments, a dissociation between dyslexic children's good morphological knowledge in spoken language, and their poor use of morphology in spelling was evident. If their difficulties with inflected forms are limited to written language, then it would have been expected that they should have had difficulties in reading regularly inflected verbs as well.

In Experiment 1, no difference was found between the SA-RA group and dyslexic group in their reading of these forms. However, it could be that the task used was not sensitive enough to assess differences between groups.

Assessing reading through reading accuracy of inflected verbs in a list form has limitations because children can read accurately without having complete lexical representations of a word. Using latencies would be more sensitive, because if dyslexic children were proportionately slower at reading inflected forms compared to one-morpheme words in comparison to a SA-RA control group, this interaction would suggest that they have less efficient access to the lexical representations of morphologically complex words.

One way of assessing specific difficulties with morphology in reading would be to use morphological priming tasks. The basic premise of such tasks is that response times to an inflected or derived form (e.g., *cars*) should yield quicker response times when the item is preceded by a stem (e.g., *car*) than an orthographically related word (e.g., *card*) (Stanners et al., 1979). Morphological priming tasks are not easy to devise due to a number of extraneous factors. For instance, a stem also shares visual similarities to an inflected or derived form, so in order to be sure that morphological priming is occurring, pseudo-suffixed words would have to be included as controls (e.g., *corn/corner; fair/fairy*). In addition, issues such as the frequency of stems and their cumulative frequency needs to be considered (see Colé et al., 1997, in Chapter 3). Despite these problems, morphological priming experiments have shown that when such factors are controlled, the presentation of a stem facilitates access to an inflected or derived form (Laudanna et al., 1989). The results of morphological priming experiments can be interpreted by both decomposed models and network accounts (Allen & Badecker, 2001).

Very few morphological priming studies have been conducted on children and only one, to my knowledge, has been conducted on dyslexic children. Leong and Parkinson (1995) showed that dyslexic children were less facilitated by morphological primes in comparison to above average readers of the same age. This type of study now needs to be conducted comparing dyslexic children with SA-RA control groups. If dyslexic children tend to store morphologically complex words as wholes, they should be less facilitated by prior presentation of a stem, which would indicate that the organisation of their lexicons differs from those of normally developing individuals.

In addition, it could be that dyslexic children's problems with morphology become more pronounced when task demands are increased. Asking children to read text containing inflected forms may have generated more errors. In order to assess whether or not difficulties with inflected forms in reading are due to problems processing inflected forms in spoken language, tasks should be presented in both oral and written formats. Egan and Pring (in press) used this type of technique to measure how quickly children make decisions about tense (i.e., deciding whether *he walks/he is walking* are in the same or different temporal tense). They showed that compared to a SA-RA control group, the dyslexic children took longer to make decisions about tense in the written, but not spoken version of the task.

In this thesis, children's spelling of inflected forms was investigated, and the area of primary interest was their spelling of the *–ed* allomorph. One limitation of focusing on this was that the children's spelling of the verbs' stems was not assessed. With hindsight, it would have been interesting to have given the children the stems of all the inflected verbs to spell, in order to assess the extent to which they retained the stem when spelling the past tense form. Studies on adults have shown that those with spelling disabilities are particularly poor at recognising the relationship between stems and their suffixed forms, so while they can spell *magic* correctly, they spell magician as *magishon, magishan* and *magition* (Carlisle, 1987).

A further area that could have been investigated was how children spelled inflected forms when processing demands were higher. However, there are difficulties using free writing samples for research because children might circumvent their difficulties with regularly inflected verb endings by using irregular verbs (e.g., *went* instead of *walked*). In the passage dictation task used in the multiple case studies, the children did not make more errors than in single word spelling. This was at odds with Hauerwas and Walker's (2003) data, which showed dyslexic children made far more errors than a SA-RA group on inflectional endings in a sentence dictation task.

Conclusions

The studies reported in this thesis showed that not all dyslexic children have difficulties with the *–ed* ending in spelling when their performance on a matched set of one-morpheme words is considered. Only around 16-17% of dyslexic children have this difficulty. In these children, their problems appear to be primarily underpinned by deficiencies of orthographic knowledge. The causes of these orthographic deficiencies remain unclear, but from the data provided here it is likely that they are due to a combination of factors: poor visual attentional processing skills, poor interaction between phonological and orthographic skills, and weak awareness of how grammar affects spelling.

The dyslexic children did differ from normally developing children of the same reading and spelling level in two respects: they did not follow the same pattern of over-generalising, and their morphological awareness, though similar to that of the SA-RA group, did not exert an impact on their use of the *–ed* ending. This finding suggests that dyslexic children do not draw upon their knowledge of morphological relations in spelling.

Making strong conclusions from the data reported here is difficult because there is still a great deal more that needs to be achieved in the area of morphology and literacy development in general. Specifically, there is a pressing need for theoretical research into the development of children's lexical representations for morphologically complex words. Such research is likely to prove problematic, because there is still no real consensus in the adult literature about lexical storage for morphologically complex words. Nevertheless, most theorists would agree that morphologically complex words are decomposed at some level in the lexicon.

Morphological priming experiments, as well as latency studies, carried out on children at different ages of development may show that at some point children's storage of morphological forms dissociates in written and spoken language, before coming together again. This would account for why, during the infant and middle school years, children perform well on spoken measures of morphological awareness, but not on spelling measures of inflected verbs. By the time they reach high school, most children would be expected to store morphologically complex words in a decomposed way in both written and spoken language. This would account for the rapid explosion in children's reading and spelling development that occurs during late childhood and the teenage years. Perhaps for dyslexic children, there is a dissociation between their processing of morphologically complex forms in spoken and written language, and this might explain why dyslexic adolescents and adults have difficulties with morphological spelling patterns (Carlisle, 1997).

A positive finding to emerge from the research was that while dyslexic children varied in their levels of morphological awareness, very few exhibited deficiencies in this linguistic domain. In some children, it was a relative strength. Consequently, remediation strategies that emphasise the link between morphology and spelling could have a great impact on dyslexic children's spelling. Conceivably, this could be achieved using some of the methods developed by Nunes and Bryant (2000). They trained normally developing children in making morphological analogies, classifying words into morphemic groups, and counting, adding, and subtracting morphemes. This training had an impact on general measures of reading and, to a lesser extent, spelling. Interestingly, it did not matter whether the training was oral or both oral and written. Furthermore, the morphological training was as good as phonological training at enhancing children's reading and spelling. As many dyslexic children have difficulties with phonology, perhaps educators should place more emphasis on the morphological features of English when teaching children with specific difficulties with literacy.

References

Ahissar, M., Protopapas, A., Reid, M., & Merzenich, M.M. (2000). Auditory processing parallels reading abilities in adults. *Proceeding of the Natural Academy of Science USA, 97*, 6832-6837.

Allen, M., & Badecker, W. (1999). Stem homograph inhibition and stem allomorphy: representing and processing inflected forms in a multilevel lexical system. *Journal of Memory and Language, 41*, 105-123.

Allen, M., & Badecker, W. (2001). Morphology: the internal structure of words. In B.C. Rapp (Ed.), *Handbook of Cognitive Neuropsychology*. Philadelphia: Psychology Press.

Amitay, S., Ben-Yehudah, G., Banai, K., & Ahissar, M. (2002). Disabled readers suffer from visual and auditory impairments but not from a specific magnocellular deficit. *Brain, 125*, 2272-2285.

Anderson, S. (1992). *A-morphous morphology*. Cambridge: Cambridge University Press.

Baddeley, A.D., Ellis, N.C, Miles, T.R., & Lewis, V.J. (1982). Developmental and acquired dyslexia: a comparison. *Cognition, 11*, 185-199.

Badecker, W., & Caramazza, A. (1991). Morphological decomposition in the lexical output system. *Cognitive Neuropsychology, 8*, 335-367.

Badecker, W., Hillis, A., & Caramazza, A. (1990). Lexical morphology and its role in the writing process: evidence from a case of acquired dysgraphia. *Cognition, 35*, 205-243.

Badecker, W., Rapp, B., & Caramazza, A. (1996). Lexical morphology and two orthographic routes. *Cognitive Neuropsychology, 13*, 161-175.

Badian, N.A. (1994). Do dyslexic and other poor readers differ in reading-related cognitive skills? *Reading and Writing: An Interdisciplinary Journal, 6, 1*, 45-63.

Barker, K., Torgesen, J.K., & Wagner, R.K. (1992). The role of orthographic processing skills on five different reading tasks. *Reading Research Quarterly 27*, 334-345.

Baron, J. (1979). Orthographic and word specific mechanisms in children's reading of words. *Child Development, 50,* 60-75.

Barron, R., & Baron, J. (1977). How children get meaning from printed words. *Child Development, 48, 587-594.*

Barry, C. (1994). Spelling routes (or roots or rutes). In G. Brown & N. Ellis (Eds.), *Handbook of spelling,* (pp 27-49). Chichester UK: J. Wiley & Sons.

Beers, C.S. & Beers, J.W. (1992). Children's spelling of English inflectional morphology. In S. Templeton & D.R. Bear (Eds.), *Development of orthographic knowledge and the foundation of literacy: A memorial Festschrift for Edmund H. Henderson* (pp. 231-252). Hillsdale, NJ: Lawrence Erlbaum.

Ben-Dror, I., Bentin, S., & Frost, R. (1995). Semantic, phonologic, and morphologic skills in reading disabled and normal children: Evidence from perception and production of spoken Hebrew. *Reading Research Quarterly 30 (4),* 876-893.

Bentin, S., & Frost, R. (1995). Morphological factors in visual word identification in Hebrew. In L. Feldman (Ed.) *Morphological aspects of language processing,* (pp. 271-292). Hillsdale, NJ: Lawrence Erlbaum.

Berko, J. (1958). The child's learning of English morphology. *Word 14,* 150-177.

Berninger, V.W., Abbott, R.D., & Shurtleff, H.A. (1990). Developmental changes in interrelationships of visible language codes, oral language codes, and reading or spelling. *Learning and Individual Differences, 2,* 45-66.

Berry, M.F. (1977). *The Berry-Talbott developmental guide to comprehension of grammar.* Rockford, IL.

Besner, D., Twilley, L., McCann, R.S. & Seergobin, K. (1990). On the connection between connectionism and data: Are a few words necessary? *Psychological Review, 97,* 432-446.

Bishop, D. V. M. (1983). *The Test for Reception of Grammar*. Published by the author and available from Age and Cognitive Performance Research Centre, University of Manchester, M13 9PL.

Bishop, D.V.M. (1997). Cognitive neuropsychology and developmental disorders: uncomfortable bedfellows. *The Quarterly Journal Experimental Psychology, 50A (4)*, 899-923.

Black, J.L., Collins, D.W.K., Deroach, J.N., & Zubrick, S. (1984). A detailed study of sequential saccadic eye movements for normal and poor reading children. *Perceptual and Motor Skills, 59*, 423-434.

Bohannon, J.N., Warren, O., Leubecker, A., & Hepler, N. (1984). Word order awareness and early reading. *Child Development, 55*, 1541-1548.

Bosse, M-L., Valdois, S., & Tainturier, M-J. (2003). Analogy without priming in early spelling development. *Reading and Writing: An Interdisciplinary Journal, 16 (7)*, 693-716.

Bowey, J.A. (1986). Syntactic awareness in relation to reading skills and ongoing reading comprehension monitoring. *Journal of Experimental Child Psychology, 41*, 282-299.

Bradley, L. & Bryant, P.E. (1978). Difficulties in auditory organisation as a possible cause of reading backwardness. *Nature, 271*, 746-747.

Bradley, L. & Bryant, P.E. (1979). Independence of reading and spelling in backward and normal readers. *Developmental Medicine and Child Neurology, 21*, 504-514.

Bradley, L. & Bryant, P.E. (1983). Categorising sounds and learning to read – a causal connection. *Nature, 301*, 419-521.

Bradley, L. & Bryant, P. (1985). *Rhyme and reason in reading and spelling*. Ann Arbor, MI: University of Michigan Press.

Brady, S., Poggle, E., & Rapala, M. (1989). An investigation of speech perception abilities in children who differ in reading skill. *Language and Speech, 32*, 109-122.

Brady, S.A. (1997). Ability to encode phonological representations: an underlying difficulty in poor readers. In Blachman, B. A. (Ed.), *Foundations of reading acquisition and dyslexia: implications for early intervention* (pp. 21-48). Mahwah, NJ: Lawrence Erlbaum Associates.

Brittain, M. (1970). Inflectional performance and early reading achievement. *Reading Research Quarterly, 6*, 34-38.

Brown, A. (1988). Encountering misspellings and spelling performance: why wrong isn't right. *Journal of Educational Psychology, 80*, 488-494.

Brown, R. (1973). *A first language*. Cambridge, MA: Harvard University Press.

Brown, R. & Cazden, C. (1968). The acquisition of noun and verb inflections. *Child Development, 39*, 433-448)

Bruce, D.J. (1964). The analysis of word sounds. *British Journal of Educational Psychology, 34*, 158-170.

Bruck, M. (1988). The word recognition and spelling of dyslexic children. *Reading Research Quarterly, 23*, 51-69.

Bruck, M. (1992). Persistence of dyslexics' phonological deficits. *Developmental Psychology, 28 (5)*, 874-886

Bruck, M. (1993). Component spelling skills of college students with childhood diagnoses of dyslexia. *Learning Disability Quarterly. Special Issue: Adults with learning disabilities, 16 (3)*, 171-184.

Bruck, M., & Treiman, R. (1990). Phonological awareness and spelling in normal children and dyslexics. *Learning Disability Quarterly, 16*, 171-184.

Brunswick, N., McCrory, E., Price, C.J., Frith, C. D., & Frith, U. (1999). Explicit and implicit processing of words and pseudowords by adult developmental dyslexics: a search for Wernicke's Wortschatz? *Brain, 122*, 1901-1917.

Bryant P.E., & Impey, L. (1986). The similarities between normal readers and developmental and acquired dyslexics. *Cognition. Special Issue: The onset of literacy, 24 (1-2)*, 121-137.

Bryant, P., Nunes, T. & Bindman, M. (1998). Awareness of language in children who have reading difficulties: historical comparisons in a longitudinal study. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 39 (4)*, 501-510.

Byrne, B. (1981). Deficient syntactic control in poor readers: Is a weak phonetic memory code responsible? *Applied Psycholinguistics, 2*, 201-212.

Bryne, B., Freebody, P., & Gates, A. (1992). Longitudinal data on the relations of word-reading strategies to comprehension, reading time, and phonemic awareness. *Reading Research Quarterly, 27*, 141-151.

Burani, C., Salmaso, D., & Caramazza, A. (1984). Morphological structure and lexical access. *Visible Language, XVIII*, 4, 342-352.

Butterworth, B. (1983). Lexical Representation. In B. Butterworth (Ed.), *Language production* (Vol 2, pp. 257-294). London: Academic Press.

Bybee, J. (1995). Regular Morphology and the Lexicon. *Language and Cognitive Processes, 10 (5)*, 425-455.

Campbell, R. (1985). When children write nonwords to dictation. *Journal of Experimental Child Psychology, 40*, 133-151.

Campbell, R. & Butterworth, B. (1985). Phonological dyslexia and dysgraphia and a highly literate subject: a developmental case with associated deficits of phonemic processing. *Quarterly Journal of Experimental Psychology, 37A*, 435-477.

Caramazza, A., & Hillis, A. (1990). Lexical organisation of nouns and verbs in the brain. *Nature, 349,* 788-790.

Caramazza, A., Laudanna, A., & Romani, C. (1988). Lexical access and inflectional morphology. *Cognition, 28,* 297-332.

Caramazza, A., Miceli, G., Silveri, M.C., & Laudanna, A. (1985). Reading mechanisms and the organisation of the lexicon: evidence from acquired dyslexia. *Cognitive Neuropsychology, 2,* 81-114.

Carlisle, J. (1987). The use of morphological knowledge in spelling derived forms by learning-disabled and normal students. *Annals of Dyslexia, 37,* 90-108.

Carlisle, J. (1995). Morphological Awareness and Early Reading Achievement. In L.B. Feldman (Ed.), *Morphological Aspects of Language Processing* (pp. 189-210). Hillsdale, NJ: Lawrence Erlbaum Associates.

Carlisle, J. F. (2000). Awareness of the structure and meaning of morphologically complex words: Impact on reading. *Reading and Writing: An Interdisciplinary Journal, 12,* 169-190.

Carlisle, J. F. & Nomanbhoy, D.M. (1993). Phonological and morphological awareness in first graders. *Applied Psycholinguistics 14,* 177-195.

Carroll, J., Davis, P. & Richman, B. (1971). *The American heritage word frequency book.* Boston: Houghton Mifflin.

Cashman, S. & Van Daal, V. *Visual recognition test.* Unpublished test. University of Wales, Bangor.

Cassar, M. & Treiman, R. (1997). The beginnings of orthographic knowledge: children's knowledge of double letters in words. *Journal of Educational Psychology, 89(4),* 631-644.

Castles, A. & Coltheart, M. (1993). Varieties of developmental dyslexia. *Cognition, 47*, 149-180.

Castles, A., Coltheart, M., Savage, G., Bates, A., & Reid, L. (1996). Morphological processing and visual word recognition: evidence from acquired dyslexia. *Cognitive Neuropsychology, 13*, 1041-1057.

Cestnik, L. & Coltheart, M. (1999). The relationship between language processing and visual processing deficits in developmental dyslexia. *Cognition, 71*, 231-255.

Chialant, D., & Caramazza, A. (1995). Where is morphology and how is it processed? The case of written word recognition. In L.B. Feldman (Ed.) *Morphological Aspects of Language Processing*, (pp 55-76). Hillsdale, NJ: Lawrence Erlbaum Associates.

Clark, M.M. (1970). *Reading Difficulties in Schools.* Harmondsworth: Penguin.

Colé, P., Beauvillain, C., & Segui, J. (1989). On the representation and processing of prefixed and suffixed derived word: a differential frequency effect. *Journal of Memory and Language, 28*, 1-13.

Colé, P., Segui, J., & Taft, M. (1997). Words and morphemes as units for lexical access. *Journal of Memory and Language, 37*, 312-330.

Coltheart, M. (1978). Lexical access in simple reading tasks,. In G. Underwood (Ed.) *Strategies of Information Processing*. London: Academic Press.

Coltheart, M. (1985). Cognitive Neuropsychology and the study of reading. In M.I. Posner & O.S.M. Martin (Eds.) *Attention and performance XI* (pp. 3-37). Hillsdale, NJ: Erlbaum.

Coltheart, M., Curtis, B., Atkins, P., & Haller, M. (1993). Models of reading aloud: dual-route and parallel-distributed processing approaches. *Psychological Review, 100 (4)*, 589-608.

Coltheart, V., Laxon, V.J., & Keating, C. (1988). Effects of word imageability and age of acquisition on children's reading. *British Journal of Psychology, 79*, 1-12.

Coltheart, V., & Leahy, J. (1992). Children's and adult's reading of nonwords: effects of regularity and consistency. *Journal of Experimental Psychology: Learning,Memory and Cognition, 18*, 718-729.

Coltheart, M., Masterson, J., Byng, S., Prior, M., & Riddoch, J. (1983). Surface dyslexia. *Quarterly Journal of Experimental Psychology, 35*, 469-496.

Coltheart, M., Patterson, K., & Marshall, J. (1980). *Deep dyslexia.* London: Routledge and Kegan Paul.

Cornelissen, P., Munro, N., Fowler, S., & Stein, J. (1993). The stability of binocular fixation during reading in adults and children. *Developmental Medicine and Child Neurology, 35*, 777-787.

Cornelissen, P., Richardson, A., Mason, A., Fowler, S., Stein, J. (1995). Contrast sensitivity and coherent motion detection measured by photopic luminance levels in dyslexics and controls. *Vision Research*, 35, 1483-1494.

Cunningham, A.E., Perry, K.E., & Stanovich, K.E. (2001). Converging evidence for the concept of orthographic processing. *Reading and Writing: An Interdisciplinary Journal, 14*, 549-568.

Cunningham, A.E. & Stanovich, K.E. (1990). Assessing print exposure and orthographic processing skill in children: a quick measure of reading experience. *Journal of Educational Psychology 82*, 733-740.

Cunningham, A.E. & Stanovich, K.E. (1993). Children's literacy environments and early word recognition skills. *Reading and Writing: An Interdisciplinary Journal, 5*, 193-204.

Cunningham, A.E., Perry, K. E., & Stanovich, K.E. (2001). Converging evidence for the concept of orthographic processing. *Reading and Writing: An Interdisciplinary Journal, 14*, 549-568.

Derwing, B.L. (1976). Morpheme recognition and the learning of rules for derivational morphology. *The Canadian Journal of Linguistics, 21 (1),* 38-66.

Derwing, B.L., Smith, M.L., & Wiebe, G.E. (1997). On the role of spelling in morpheme recognition: Experimental studies with children and adults. In L. B. Feldman (Ed). *Morphological aspects of language processing.* (pp. 3-28). Hillsdale, NJ: Lawrence Erlbaum Associates.

De Villiers, J.G. & De Villiers, P.A. (1973). A cross-sectional study of the acquisition of grammatical morphemes in child speech. *Journal of Psycholinguistic Research, 2,* 267-278.

Deacon, S.H. & Bryant, P.E. (2001). Children's use of base words to spell derived and inflected forms: Beyond phonological and orthographic similarity. Poster presented at Scientific Studies in Reading. Boulder, CO.

DeFries, J.C., Stevenson, J., Gillis, J.J., & Wadsworth, S.J. (1991). Genetic aetiology of spelling deficits in the Colorado and London twin studies of reading disability. *Reading and Writing, 3,* 271-283.

Denckla, M.B. & Rudel, R.G. (1976a). Naming of object drawings by dyslexic and other learning disabled children. *Brain and Language, 3,* 1-15.

Denckla, M.B., & Rudel, R.G. (1976b). Rapid automatized naming (RAN): Dyslexia differentiated from other learning disabilities. *Neuropsychologia, 14,* 471-479.

Derwing, B.L. (1976). Morpheme recognition and the learning of rules for derivational morphology. *Canadian Journal of Psycholinguistics, 21,* 38-66.

Derwing, B.L., & Nearey, T.M. (1991). The 'vowel stickiness' phenomenon: Three experimental sources of evidence. Paper presented at the Twelfth International Congress of Phonetic Sciences, Aix-en-Provence, France.

Deutsch, A., & Bentin, S. (1996). Attention factors mediating syntactic deficiency in reading-disabled children. *Journal of Experimental Child Psychology, 63,* 386-415.

Dixon, M., Stuart, M., & Masterson, J. (2002). The relationship between phonological awareness and the development of orthographic representations. *Reading and Writing: An Interdisciplinary Journal 15*, 295-316.

Doehring, D., Trites, R., Patel, P., & Fiedorowicz, C. (1981). *Reading disabilities: The interaction of reading, language and neuropsychological deficits.* New York: Academic Press.

Drews, E., & Zweitserlood, P. (1995). Morphological and orthographic similarity in visual word recognition. *Journal of Experimental Psychology: Human Perception and Performance, 21*, 1098-1116.

Dunn, L.M., & Dunn, L.M. (1992). British Picture Vocabulary Scale. Windsor, UK: NFER-Nelson..

Eden, G.F., Van Meter, J. W., Rumsey, J. M., Maisog, J.M., Woods, R. P., Zeffiro, T. A. (1996). Abnormal processing of visual motion in dyslexia revealed by functional brain imaging. *Nature, 382*, 66-69.

Egan, J., & Pring, L. (in press). The processing of inflectional morphology: A comparison of children with and without dyslexia. *Reading and Writing: An Interdisciplinary Journal.*

Egan, J., & Tainturier, M.J. (in preparation). Learning to spell English past tense inflectional morphology: rules or rote? Manuscript in preparation, University of Wales, Bangor, UK.

Ehri, L. (1980). The development of orthographic images. In U.Frith (Ed.), *Cognitive processes in spelling* (pp 311-338). London: Academic Press

Ehri, L. (1986). Sources of difficulty in learning to spell and read. In M. Wolraich & D. Routh (Eds.), *Advances in developmental and behavioral pediatrics* (pp 121-195). Greenwich, CT: Jai.

Ehri, L. (1991). Development of the ability to read words. In R.Barr, M. Kamil, P. Mosenthal, P. Pearson (Eds.), *Handbook of reading research.* New York: Longman, 383-417.

Ehri, L. (1994). Development of the ability to read words: Update. In R. Ruddell, M. Ruddell, & H. Singer (Eds.), *Theoretical models and processes of reading* (4^{th} Ed. Pp. 323-358). Newark, DE: International Reading Association.

Ehri, L. (1995). Phases of development in learning to read words by sight. *Journal of Research in Reading, 18,* 116-125.

Ehri, L. (1997) Learning to read and learning to spell are one and same, almost. In C.A.Perfetti, L. Rieben, & M. Fayol (Eds.) *Learning to Spell: Research, Theory, and Practice Across Languages.* (pp 237-269). Mahwah, NJ: Lawrence Erlbaum Associates.

Ehri, L., & Wilce, L. (1980). The influence of orthography on readers' conceptualisation of the phonemic structure of words. *Applied Psycholinguistics, 1,* 371-385.

Ehri, L. & Wilce, L. (1987a). Cipher versus cue reading: An experiment in decoding acquisition. *Journal of Educational Psychology, 79,* 3-13.

Ehri, L. & Wilce, L. (1987b). Does learning to spell help beginners learn to read words? *Reading Research Quarterly, 22,* 47-65.

Ehri, L., & Saltmarsh, J. (1995). Beginning readers outperform older disabled readers in learning to read words by sight. *Reading and Writing: An Interdisciplinary Journal,* 7, 295-326.

Ehri, L.C., & Wilce, L.S. (1985). Movement into reading: Is the first stage of printed word learning visual or phonetic? *Reading Research Quarterly, 20,* 163-179.

Eichelman, W. H. (1970). Familiarity effects in the simultaneous matching task. *Journal of Experimental Psychology, 86,* 275-282.

Elbro, C. (1989). Morphological awareness in dyslexia. In C. von Euler (Ed.), *Wenner-Gren International Symposium Series: Brain and Reading.* Hampshire, England: Macmillan.

Elbro, C., & Arnbak, E. (1996). The role of morpheme recognition and morphological awareness. *Annals of Dyslexia, 46*, 209-240.

Ellis, A. W. (1993). *Reading, Writing, and Dyslexia* (2nd ed.). Hove: Lawrence Erlbaum Associates.

Ellis, N. (1981). Visual and name coding in dyslexic children. *Psychological Research, 43, 201-18.*

Ellis, N. (1997). Interactions in the development of reading and spelling: stages, strategies, and exchange of knowledge. In C.A.Perfetti, L. Rieben, & M. Fayol (Eds.) (pp. 271-294). *Learning to Spell: Research, Theory, and Practice Across Languages* Mahwah, NJ: Lawrence Erlbaum Associates.

Ellis, N.C., & Hennelly, R.A. (1980). A bilingual word-length effect: Implications for intelligence testing and the relative ease of mental calculation in Welsh and English. *British Journal of Psychology, 71*, 43-52.

Ellis, N.C., & Large, B. (1987). The development of reading: as you seek so shall you find. *British Journal of Psychology, 78*, 1-28.

Emmorey, K. D. (1989) Auditory morphological priming in the lexicon. *Language and Cognitive Processes, 4*, 73-92.

Farmer, M.E., & Klein, R. M. (1995). The evidence for a temporal processing deficit linked to dyslexia: A review. *Psychonomic Bulletin Review, 2*, 460-493.

Fawcett, A.J., & Nicolson, R.I. (1992). Automatisation deficits in balance for dyslexic children. *Perceptual & Motor Skills, 75, 2,* 507-529.

Fawcett, A.J., & Nicolson, R.I. (1995a). Persistence of phonological awareness deficits in older children with dyslexia. *Reading and Writing: An Interdisciplinary Journal, 7, 4,* 361-376.

Fawcett, A.J., & Nicolson, R.I. (1995b). Persistent deficits in motor skill of children with dyslexia. *Journal of Motor Behaviour, 27, 3,* 235-240.

Fawcett, A.J., & Nicolson, R.I. (1999). Performance of dyslexic children on cerebellar and cognitive tests. *Journal of Motor Behaviour, 31, 1,* 68-78.

Fawcett, A.J., Nicolson, R.I., & Dean, P. (1996). Impaired performance of children with dyslexia on a range of cerebellar tasks. *Annals of Dyslexia, 46,* 259-283.

Felton, R.H., & Wood, F.B. (1992). A reading level match study of nonword reading skills in poor readers with varying IQs. *Journal of Learning Disabilities, 25,* 318-326.

Fischer, F.W., Shankweiler, D., & Liberman, I.Y. (1985). Spelling proficiency and sensitivity to word structure. *Journal of Memory and Language, 24,* 282-295.

Flood, J., & Menyuk, P. (1983). The development of metalinguistic awareness and its relation to reading achievement. *Journal of Applied Developmental Psychology, 4,* 65-80.

Foorman, B., Francis, D., Novy, D., & Liberman, D. (1991). How letter-sound instruction mediates progress in first grade reading and spelling. *Journal of Educational Psychology, 83,* 456-469.

Fowler, A.E. (1988). Grammaticality judgements and reading skill in grade 2. *Annals of Dyslexia, 38,* 73-94.

Fowler, A.E., & Liberman, I.Y. (1995). The role of phonology and orthography in Morphological Awareness. In L.B. Feldman (Ed). *Morphological aspects of language processing.* (pp 157-188). Hillsdale, NJ: Lawrence Erlbaum Associates.

Frederickson, N., Frith, U., & Reason, R. (1997). *The Phonological Assessment Battery.* NFER Nelson.

Frisson, S., & Sandra, D. (2001). Homophonic forms of regularly inflected verbs have their own orthographic representations: A developmental perspective on spelling errors. *Brain and Language, 81*, 545-554.

Frith, U. (1985). Beneath the surface of surface dyslexia. In K.E., Patterson, J.R., Marshall, & M. Coltheart. (Eds.), *Surface Dyslexia*, Hillsdale, NJ: Lawrence Erlbaum.

Frith, U. (1997). Brain, Mind and Behaviour in Dyslexia. In C. Hulme, & M. Snowling (Eds.). *Dyslexia: Biology, Cognition, and Intervention* (pp. 59-71). London: Whurr,

Funnell, E. (1983). Phonological processes in reading: New evidence from acquired dyslexia. *British Journal of Psychology, 74,* 159-180.

Funnell, E. (1987). Morphological errors in acquired dyslexia: A case of mistaken identity. *The Quarterly Journal of Experimental Psychology, 39A*, 497-539.

Funnell, E. & Davidson, M. (1989). Lexical capture: A developmental disorder of reading and spelling. *Quarterly Journal of Experimental Psychology, 41A*, 471-487.

Galaburda, A. M., & Livingstone, M.S. (1993). Evidence for a magnocellular defect in developmental dyslexia. *Annals of the New York Academy of Sciences, 682,* 70-82.

Galaburda, A.M., Menard, M. T., & Rosen, G.D. (1994). Evidence for aberrant auditory anatomy in developmental dyslexia. *Proceedings of the National Academy of Science USA, 913*, 8010-8013.

Galaburda, A.M., Sherman, G.F., Rosen, G.D., Abiotiz, F., & Geschwind, N. (1985). Developmental dyslexia: Four consecutive patients with cortical abnormalities. *Annals of Neurology, 18*, 222-233.

Gathercole, S.E., Willis, C.S., Baddeley, A.D., & Emslie, H. (1994). The Children's Test of nonword repetition: A test of phonological working memory. *Memory. Special Issue: Memory tests and techniques, 2, 2,* 103-127.

Gentry, J.R. (1982). An analysis of developmental spelling in GNYS AT WORK. *The Reading Teacher, 36,* 192-200.

Geschwind, N., & Galaburda, A.M. (1985). Cerebral lateralisation: Biological mechanisms, associations and pathology. *Archives of Neurology, 42,* 428-459.

Godfrey, J.J., Syrdal-Lasky, A.K., Millay, K.K., & Knox, C.M. (1981). Performance of dyslexic children on speech perception tests. *Journal of Experimental Child Psychology, 32,* 401-424.

Goldman, S.R. (1976). Reading skill and the minimum distance principle. A comparison of listening and reading comprehension. *Journal of Experimental Child Psychology, 22,* 123-142.

Goswami, U. (1986). Children's use of analogy in learning to read: A developmental study. *Journal of Experimental Child Psychology, 42,* 73-83.

Goswami, U. (1988). Children's use of analogy in learning to spell. *British Journal of Developmental Psychology, 6, 1,* 21-33.

Goswami, U. (1991). Learning about spelling sequences: The role of onsets and rimes in analogies in reading. *Child Development, 62, 5,* 1110-1123.

Goswami, U. (1992). Phonological factors in spelling development, *Journal of Child Psychology & Psychiatry & Allied Disciplines, 33, 6,* 967-975

Goswami, U. (1993). Toward an interactive analogy model of reading development: Decoding vowel graphemes in beginning reading. *Journal of Experimental Child Psychology, 56,* 443-475.

Goswami, U., & Bryant, P. (1990). *Phonological Skills and Learning to read.* Essays in developmental psychology series. Hove, England UK: Lawrence Erlbaum Associates.

Goswami, U., & Mead, F. (1992). Onset and rime awareness and analogies in reading. *Reading Research Quarterly, 27*, 152-162.

Goulandris, N.K., & Snowling, M. (1991). Visual Memory Deficits: A Plausible Cause of Developmental Dyslexia? Evidence from a single case study. *Cognitive Neuropsychology, 8, 2,* 127-154.

Goulandris, N.K., McIntyre, A., & Snowling, M. (1998). Fixed reference eye and reading disability: Is there a connection? In C. Hulme & R.M. Joshi (Eds.) *Reading and spelling: Development and disorders.* (pp. 303-315). Mahwah, NJ: Lawrence Erlbaum Associates.

Grainger, J., Colé, P., & Segui, J. (1991). Masked morphological priming in visual word recognition. *Journal of Memory and Language, 30*, 370-384.

Grant, A.C., Zangaladze, A., Thiagarajah, M., & Saathian, K. (1999). Tactile perception in dyslexics. *Neuropsychologia, 37*, 1201-1211.

Guthrie, T.T. (1973). Reading comprehension and syntactic response in good and poor readers. *Journal of Educational Psychology, 65*, 294-299.

Hanley, J.R., Hastie, K., & Kay, J. (1991). Developmental surface dyslexia and dysgraphia: An orthographic processing impairment. *Quarterly Journal of Experimental Psychology, 44*, 285-319.

Hanson, V.L., Shankweiler, D., & Fischer, I.Y. (1983). Determinants of spelling ability in deaf and hearing adults: Access to linguistic structure. *Cognition, 14,* 323-344.

Hatcher, P.J., Hulme, C., & Ellis, A.W. (1994). Ameliorating early reading failure by integrating the teaching of reading and phonological skills: The phonological linkage hypothesis. *Child Development, 65*, 41-57.

Hauerwas, L. B., & Walker, J. (2003). Spelling of inflected verb morphology in children with spelling deficits. *Learning Disabilities Research and Practice, 18 (1)*, 25-35.

Heath, S.M., Hogben, J. H., & Clark, C. D. (1999). Auditory temporal processing in disabled readers with and without oral language delay. *Journal of Child Psychology and Psychiatry, 40*, 637-647.

Henderson, A.J. & Shores, R.E. (1982). How learning disabled student's failure to attend to suffixes affects their oral reading performance. *Journal of Learning Disabilities, 15*, 178-182.

Henderson, E. (1985). *Teaching spelling.* Boston: Houghton Mifflin.

Hogben, J.H. (1997). How does a visual transient deficit affect reading? In C. Hulme, & M. Snowling (Eds.). *Dyslexia: Biology, Cognition, and Intervention* (pp 59-71). London: Whurr.

Hulme, C. & Snowling, M. (1992). Deficits in output phonology: An explanation of reading failure. *Cognitive Neurosychology, 9*, 47-72.

Hyams, N.M. (1986b). *Language acquisition and the theory of parameters.* Dordrecht: D. Reidel.

Joanisse, M.F., Manis, F.R., Keating, P., & Seidenberg, M. S. (2000). Language Deficits in Dyslexic Children: Speech Perception, Phonology, & Morphology. *Journal of Experimental Child Psychology, 77*, 30-60.

Job, R., & Sartori, G. (1984). Morphological decomposition: Evidence from crossed phonological dyslexia. *Quarterly Journal of Experimental Psychology, 36A*, 435-458.

Johannes, S., Kussmaul, C.L., Munte, T.F., & Mangun, G.R. (1996). Developmental dyslexia: passive visual stimulation provides no evidence for a magnocellular processing defect. *Neuropsychologia, 34*, 1123-1127.

Johnson, D.J., & Grant, J.O. (1989). Written narratives of normal and learning disabled children. *Annals of Dyslexia, 39,* 140–159.

Johnston, R.S. (1983). Developmental deep dyslexia? *Cortex, 19,* 133-140.

Jones, N. K. (1991). Development of morphophonetic segments in children's mental representations of words. *Applied Psycholinguistics, 12,* 217-239.

Kean, M.L. (1989). Grammatical capacity and developmental dyslexia: Issues for research, in C. von Euler, I. Lundberg, & G. Lennerstrand (Eds.), *Brain and Reading, Wenner-Gren International Symposium Series, Vol 54* (pp. 269-278). New York: Stockton Press.

Kemp, N., & Bryant, P. (2003). Do beez buzz? Rule-based and frequency-based knowledge in learning to spell plural *–s. Child Development, 74, 1,* 63-74.

Kibel, M., & Miles, T.R. (1994). Phonological errors in the spelling of taught dyslexic children. In C. Hulme & M. Snowling (Eds.) *Reading development and dyslexia* (pp. 105-127). London: Whurr.

Kirtley, C., Bryant, P., MacLean, M., & Bradley, L. (1989). Rhyme, rime and the onset of reading. *Journal of Experimental Child Psychology, 48,* 224-245.

Kronbichler, M., Hutzler, F., & Wimmer, H. (2002). Dyslexia: Verbal impairments in the absence of magnocellular impairments. *Neuroreport, 13,* 617-620.

Laudanna, A., Badecker, W., & Caramazza, A. (1989). Priming homographic stems. *Journal of Memory and Language, 28,* 531-546.

Laudanna, A., Badecker, W., & Caramazza, A. (1992). Processing inflectional and derivational morphology. *Journal of Memory and Language,* 31, 333-348.

Lennox, C., & Siegel, L. (1998). Phonological and orthographic processes in good and poor spellers. In C. Hulme & R. M. Joshi (Eds.), *Reading and spelling development and disorders* (pp. 395-404). Mahwah, NJ: Lawrence Erlbaum Associates.

Leong, C.K. (2000). Rapid processing of base and derived forms of words and grades 4, 5, and 6 children's spelling. *Reading and Writing: An Interdisciplinary Journal 12,* 277-302.

Leong, C.K., & Parkinson, M.E. (1995). Processing of English morphological structure by poor readers in C.K. Leong & R.M. Joshi (Eds.*) Developmental and acquired dyslexia: Neuropsychological and neurolinguistic perspectives. Neuropsychology and cognition, Vol. 9* (pp 237-261). Dordrecht, Netherlands: Kluwer Academic Publishers.

Liberman, I., & Shankweiler, D. (1985). Phonology and the problems of learning to read and write. *Remedial and Speech Education, 6,* 8-17.

Lie, A. (1991). Effects of a training program for stimulating skills in word analysis in first-grade children. *Reading Research Quarterly, 26,* 234-250.

Livingstone, M.S., Rosen, G.D., Drislane, F.W., & Galaburda, A.M. (1991). Physiological and anatomical evidence for a magnocellular defect in developmental dyslexia. *Proceedings of the Natural Academy of Science USA. 88,* 7943-7947.

Locke, J.L., Hodgson, J., Macaruso, P., Roberts, J., Lamrecht-Smith, S., & Guttentag , C. (1997). The Development of Developmental Dyslexia. In C. Hulme & M. Snowling. (Eds.) *Dyslexia: Biology, Cognition, and Intervention* (pp. 72-96). London: Whurr.

Lovegrove, W.J., Bowling, A., Badcock, B., & Blackwood, M. (1980). Specific reading disability: Differences in contrast sensitivity as a function of spatial frequency. *Science, 210,* 439-440.

Lubs, H.A., Rabin, M., Feldman, E., Jallad, B.J., Kushch, A., Gross-Glenn, K., Duara, R., & Elston, R.C. (1993). Familial dyslexia: Genetic and medical findings in eleven three-generation families. *Annals of Dyslexia, 28,* 44-60.

Lukatela, G., & Turvey, M.T. (1994). Visual lexical access is initially phonological: Evidence from associative priming by words, homophones, and pseudohomophones. *Journal of Experimental Psychology: General 123,* 1-20.

Lukatela, G., Gligorijevic, B., & Kostic, A. (1980). Representation of inflected nouns in the internal lexicon. *Memory and Cognition, 8,* 415-423.

Lundberg, I., Frost, J., & Peterson, O. (1988). Effects of an extensive program for stimulating phonological awareness in pre-school children. *Reading Research Quarterly, 23,* 263-284.

Lyytinen, H. (1997). In search of the precursors of dyslexia: a prospective study of children at risk for reading problems. In C. Hulme & M. Snowling (Eds.) *Dyslexia: Biology, Cognition, and Intervention* (pp. 97-107). London: Whurr.

Mahony, D., Singson, M., & Mann, V. (2000). Reading ability and sensitivity to morphological relations. *Reading and Writing: An Interdisciplinary Journal 12,* 191-218.

Manelis, L., & Tharp, B.A. (1977). The processing of affixed words. *Memory and Cognition, 5/6,* 690-695.

Manis, F.R., Seidenberg, M.S., Doi, L.M, McBride-Chang, C., & Peterson, A. (1996). On the bases of two subtypes of development dyslexia. *Cognition, 58,* 157-195.

Mann, V.A., & Ditunno, P. (1990). Phonological deficiencies: Effective predictors of future reading problems. In G. Pavlidis (Ed.) *Perspectives on dyslexia, Vol 2.* (pp. 105-131). New York: Wiley.

Marchman, V.A., Wulfeck, B., & Weismer, S.E. (1999). Morphological productivity in children with normal language and SLI: A study of the English past tense. *Journal of Speech, Language, and Hearing Research, 42,* 206-219.

Marcus, S.G., Pinker, S., Ullman, M., Hollander, M., Rosen, J., & Xu, F. (1992). Overregularisation in language acquisition. *Monographs of the Society for Research in Child Development*, 57, Serial No. 228.

Marsh, G., Friedman, M., Welch, V., & Desberg, P. (1981). A cognitive-developmental approach to reading acquisition. In T.G. Waller & G.E. MacKinnon (Eds.), *Reading research: Advances in theory and practice, Vol. 3*. New York: Academic Press.

Marshall, J.C., & Newcombe, F. (1976). Patterns of paralexia: A psycholinguistic approach. *Journal of Psycholinguistic Research, 2,* 175-199.

Martin, F., & Lovegrove, W.J. (1987). Flicker contrast sensitivity in normal and specifically disabled readers. *Perception, 16,* 215-221.

Martlew, M. (1992). Handwriting and spelling: Dyslexic children's abilities compared with children of the same chronological age and younger children of the same spelling level. *British Journal of Educational Psychology, 62,* 375-390.

McAnally, K., & Stein, J.F. (1996). Auditory temporal coding in dyslexia. *Proceedings of the Natural Academy of Science USA, 263,* 961-965.

McArthur, G.M., & Bishop, D.V.M. (2001). Auditory perceptual processing in people with reading and oral language impairments: Current issues and recommendations. *Dyslexia, 7,* 150-170.

McArthur, G.M., & Hogben, J.H. (2001). Auditory backward recognition masking in children with a specific language impairment and children with a specific reading disability. *Journal of the Acoustic Society of America, 109,* 1092-1100.

McCann, R.S., & Besner, D. (1987). Reading pseudohomophones: implications for models of pronunciation assembly and the locus of frequency effects in naming. *Journal of Verbal Learning and Verbal Behaviour, 13,* 13-24.

McClelland, J.L., & Rumelhart, D.E. (1981). An interactive activation model of context effects in letter perception: Part 1. An account of basic findings. *Psychological Review, 88,* 375-407.

McCrory, E., Frith, U., Brunswick, N., & Price, C. (2000). Abnormal functional activation during a simple word repetition task: A PET study of adult dyslexics. *Journal of Cognitive Neuroscience, 12,* 753-762.

Meunier, F., & Segui, J. (1999). Morphological Priming Effect: the role of surface frequency. *Brain and Language, 68,* 45-60.

Meyer, D.E., & Schvaneveldt, R.W. (1971). Facilitation in recognising pairs of words: Evidence of dependence between retrieval operations. *Journal of Experimental Psychology, 90,* 227-234.

Miles, T. R. (1983). *Dyslexia: The pattern of difficulties.* London: Granada.

Moats, L.C. (1983). A comparison of the spelling errors of older dyslexic and second-grade normal children. *Annals of Dyslexia, 33,* 121-139.

Mody, M., Studdert-Kennedy, M., & Brady, S. (1997). Speech perception deficits in poor readers: auditory processing or phonological coding? *Journal of Experimental Child Psychology, 64,* 199-231.

Monsell, S. (1991). The nature and locus of word frequency effects in reading. In D. Besner & G.W. Humphreys (Eds.), *Basic processes in reading: Visual word recognition.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Morais, J., Mousty, P., & Kolinsky, R. (1998). Why and how phoneme awareness helps learning to read. In C. Hulme, & R. M. Joshi (Eds.), *Reading and Spelling: Development and Disorders.* (pp. 127-152). Mahwah, NJ: Lawrence Erlbaum Associates.

Morais, J., Cary, L., Alegria, J., & Bertelson, P. (1979). Does awareness of speech as a sequence of phones arise spontaneously? *Cognition, 7,* 323-331.

Morehead, D. & Ingram, D. (1973). The development of base syntax in normal and linguistically deviant children. *Journal of Speech and Hearing Research, 16,* 330-352.

Morton, J. (1969). Interaction of information in word recognition. *Psychological Review, 76,* 165-178.

Morton, J. (1979). Word recognition. In J. Morton & J.C. Marshall. (Eds.), *Psycholinguistic series* (pp. 107-155). Cambridge, Mass: MIT press.

Murrell, G.A., & Morton, J. (1974). Word recognition and morphemic structure. *Journal of Experimental Psychology, 102,* 963-968.

Muter, V. (1998). Phonological Awareness: Its nature and its influence over early literacy development. In C. Hulme, & R. M. Joshi (Eds.), *Reading and Spelling: Development and Disorders* (pp. 113-126). Mahwah, NJ: Lawrence Erlbaum Associates.

Muter, V., & Snowling, M. (1997). Grammar and phonology predict spelling in middle childhood. *Reading and Writing: An Interdisciplinary Journal 9, 5-6,* 407-425.

Myklebust, H. (1965). *Development and disorders of written language* (Vol. 1). New York: Grune and Stratton.

Nagy, W. & Anderson, R.C. (1984). How many words are there in printed school English? *Reading Research Quarterly 19,* 304-330.

Nation, K., & Hulme, C. (1998). Phonemic segmentation, not onset-rime segmentation, predicts early reading and spelling skills. Response. *Reading Research Quarterly, 33, 3,* 264-265.

National Literacy Strategy. (1998). (2nd Edition). Sudbury: DfEE Publications.

Neale, M.D. (1997). Neale Analysis Of Reading Ability: Second Revised (British Edition). NFER Nelson. Windsor, UK.

Nelson, H. E. (1980). Analysis of spelling errors in normal and dyslexic children. In U. Frith, (Ed.), *Cognitive processes in spelling.* (pp. 475-493). London: Academic Press

Nelson, H. & Warrington, E.K. (1980). An investigation of memory functions in dyslexic children. *British Journal of Psychology, 71,* 487-503.

Newcombe, F., & Marshall, J.C. (1981). On psycholinguistic classification of the acquired dyslexias. *Bulletin of the Orton Society, 31,* 29-44.

NFER-Nelson Verbal And Non-Verbal Reasoning Test Series (1993). NFER Nelson: Windsor, UK.

Nicolson, R. I., & Fawcett, A. J. (1990). Automaticity: A new framework for dyslexia research? *Cognition, 35, 2,* 159-182.

Nicolson, R. I. & Fawcett, A. J. (1994). Comparison of deficits in cognitive and motor skills among children with dyslexia. *Annals of Dyslexia, 44,* 147-164.

Nicolson, R.I., Fawcett, A.J., & Dean, P. (1995). Time estimation deficits in developmental dyslexia: Evidence of cerebellar involvement. *Proceedings of the Royal Society of London Series B-Biological Sciences, 259,* 43-47.

Nicolson, R.I., Fawcett, A.J., Berry, E.L., Jenckins, I. H., Dean, P., & Brooks, D.J. (1999). Association of abnormal cerebellar activation with motor learning difficulties in dyslexic adults. *Lancet, 353,* 1662-1667.

Nunes Carraher, T. (1985). Exploracoes sobre o desenvolvimento da competencia em orografia em portugues [Exploring the development of spelling in Portuguese]. *Psicologia, Teoria e Pesquisa, 1,* 269-285.

Nunes, T., Bryant, P., & Bindman, M. (1997a). Morphological spelling strategies: Developmental stages and processes. *Developmental Psychology, 33, 4,* 637-649.

Nunes, T., Bryant, P., & Bindman, M. (1997b). Learning to spell regular and irregular verbs. *Reading and Writing: An Interdisciplinary Journal, 9, 5-6,* 427-449.

Nunes, T., & Bryant, P. (2000). A step after phonics. *Literacy Today, Sept,* 24-25.

Olsen, R. K. (1985). Disabled reading processes and cognitive profiles. In D. Gray & J. Kavanagh (Eds.), *Biobehavioural measures of dyslexia* (pp. 215-243). Parkton, MD: York Press.

Olson, R., Forsberg, H., Wise, B., & Rack, J. (1994). Measurement of word recognition, orthographic, and phonological skills. In G.R. Lyon (Ed.), *Frames of reference for the assessment of learning disabilities* (pp. 243-277). Baltimore, MD: Brookes.

Olsen, R., Wise, B., Conners, F., & Rack, J., & Fulker, D. (1989). Specific deficits in component reading and language skills: Genetic and environmental influences. *Journal of Learning Disabilities, 22*, 339-348.

Olson, R.K., Kliegl, R., & Davidson, B.J. (1983). Development of phonological memory in disabled and normal readers. *Journal of Experimental Child Psychology, 37*, 187-206.

Patterson, K.E., Marshall, J.C., & Coltheart, M. (1985). *Surface dyslexia: Neuropsychological and cognitive studies of phonological reading.* Hove, UK: Lawrence Erlbaum Associates.

Paulesu, E., Frith, U., Snowling, M., Gallagher, A., Morton, A., Frackowiak, R.S.J., et al. (1996). Is developmental dyslexia a disconnection syndrome? Evidence from PET scanning. *Brain, 119 (Pt 1)*, 143-157.

Pavlidis, G.T. (1981). Do eye movements hold the key to dyslexia? *Neuropsychologia, 19*, 57-64.

Pennington, B.F., McCabe, L. L., Smith, S.D., Lefly, D.L., Bookman, M. O., Kimberling, W. J., & Lubs, H. A. (1986). Spelling errors in adults with a form of familial dyslexia. *Child Development, 57*, 159-192.

Piaget, J. (1971). *Structuralism.* London: Routledge and Kegan Paul.

Pine, J., & Lieven, E. (1997). Slot and frame patterns in the development of the determiner category. *Applied Psycholinguistics, 18*, 123-138.

Pinker. S., & Prince, A. (1992). Regular and irregular morphology and the psychological status of rules of grammar. *Proceedings of the 17th Annual Meeting of the Berkeley Linguistics Society.* Berkeley, CA: Berkeley Linguistics Society.

Pizzuto, E., & Caselli, M.C. (1992). The acquisition of Italian morphology: Implications for models of language development. *Journal of Child Language, 19*, 491-557.

Plaut, D.C., McClelland, J.L., Seidenberg, L.S., & Patterson, K.K. (1996). Understanding normal and impaired word reading: Computational principles in quasi-regular domains. *Psychological Review, 103*, 377-500.

Pring, L., & Snowling, M.J. (1986). Developmental changes in word recognition: an information processing account. *Quarterly Journal of Experimental Psychology, 36A*, 395-418.

Pugh, K.R., Mencl, W.E., Shaywitz, B.A., Shaywitz S.E., Fulbright, R. K., Constable, R.T., et al. (2000). The angular gyrus in developmental dyslexia: Task-specific differences in functional connectivity within posterior cortex. *Psychological Science, 11*, 51-56.

Pumfrey, P. D., & Reason, R. (1991). *Specific Learning Difficulties (Dyslexia): Challenges and Responses*. London: Routledge.

Rack, J. (1985). Orthographic and phonetic encoding in normal and dyslexic readers. *British Journal of Psychology, 76*, 325-340.

Rack, J.P., Hulme, C., Snowling. M., & Wightman, J. (1994). The role of phonology in young children learning to read words: The direct-mapping hypothesis. *Journal of Experimental Child Psychology 39*, 321-339.

Rack, J.P., Snowling, M.J., & Olson, R.K. (1992). The nonword reading deficit in developmental dyslexia: a review. *Reading Research Quarterly, 27, 1*, 28-53.

Rae, C., Lee, M.A., Dixon, R. M., Blamire, A.M., Thompson, C. H., Styles, P., Talcott, J., Richardson, A.J., & Stein, J.F. (1998). Metabolic abnormalities in developmental dyslexic detected by J-1 magnetic resonance spectroscopy. *Lancet, 351*, 1849-1852.

Ramaa, S., Miles, T R., & Lalithamma, M S. (1993). Dyslexia: Symbol processing difficulty in the Kannada language. *Reading and Writing: An Interdisciplinary Journal, 5, 1*, 29-41.

Ramus, F. (2001). Outstanding questions about phonological processing in dyslexia. *Dyslexia, 7,* 197-216.

Ramus, F., Rosen, S., Dackin, S. C., Day, B. L., Castellote, J. M., White, S., & Frith, U. (2003a). Theories of developmental dyslexia: Insights from a multiple case study of dyslexic adults. *Brain, 126, 4,* 841-865.

Ramus, F., Pidgeon, E., & Frith, U. (2003b). The relationship between motor control and phonology in dyslexic children. *Journal of Child Psychology and Psychiatry.* In press.

Raven, J.C. (1958). *Standard Progressive Matrices.* London: H.K. Lewis.

Rayner, K. (1978a). Eye movements in reading and information processing. *Psychological Bulletin, 85,* 618-660.

Reitsma, P. (1983). Printed word learning in beginning readers. *Journal of Experimental Child Psychology, 75,* 321-339.

Rice, M. & Wexler, K., & Cleave, P. (1995). Specific language impairment as a period of extended optional infinitive. *Journal of Speech and Hearing Research, 38,* 850-863.

Rosen, S., & Manganari, E. (2001). Is there a relationship between speech and nonspeech auditory processing in children with dyslexia? *Journal of Speech, Language and Hearing Research, 44,* 720-736.

Rubin, G.S., Becker, C.A., & Freeman, R.H. (1979). Morphological structure and its effect on visual word recognition. *Journal of Verbal Learning and Verbal Behaviour, 18,* 727-767.

Rubin, H. (1988). Morphological knowledge and early writing ability. *Language and Speech, 31,* 337-355.

Rutter, M., & Yule, W. (1975). The concept of specific reading retardation. *Journal of Child Psychology and Psychiatry, 16,* 181-197.

Sandra, D., Frisson, S., & Daems, F. (1999). Why simple verbs can be so difficult to spell: The influence of homophonic frequency and distance in Dutch. *Brain and Language, 68,* 277-283.

Scarborough, H. S. (1990). Very early language deficits in dyslexic children. *Child Development, 61,* 1728-1743.

Schonell, F. G. (1956). The Graded Word Spelling Test. Edinburgh: Goodacre.

Schreuder, R., Grendel, M., Poulisse, N., Roelofs, A., & Van de Voort, M. (1990). Lexical processing, morphological complexity, and reading. In D.A. Balota, G.B. Flores d'arcais, & K.Rayner (Eds.) *Comprehension Processes in Reading* (pp. 125-141). Hillsdale, NJ: Lawrence Erlbaum Associates.

Schreuder, R., & Baayen, H. (1995). Modelling morphological processing. In L. Feldman (Ed.) *Morphological aspects of language processing* (pp. 131-156). Hillsdale, NJ: Lawrence Erlbaum. Associates.

Schriefers, H., Frederici, A., & Graetz, P. (1992). Inflectional and derivational morphology in the mental lexicon: symmetries and asymmetries in repetition priming. *Quarterly Journal of Experimental Psychology, 44A,* 373-390.

Schrieders, H., Zwietserlood, P., & Roelofs, A. (1991). The identification of morphologically complex words: Continuous processing or decomposition? *Journal of Memory and Language, 30,* 26-47.

Schwartz, M.F., Saffran, E.M., & Marin, O.S.M. (1980). Fractionating the reading process in dementia: Evidence for word-specific print-to-sound associations. In M. Colthearrt, K. Patterson, & J.C. Marshall (Eds.), *Deep Dyslexia.* London: Routledge & Kegan Paul.

Sebastián, E., Soto, P., & Gathercole, V.C.M. (2001). Early verb constructs in Spanish. In I. Idiazabal (Ed.), *Proceedings of the VIII International Congress for the Study of Child Language: Volume 2: Syntax, morphology, phonology, and the lexicon.* Cascadilla Press.

Segui, J., & Zubizarreta, M.L. (1985) . Mental representation of morphologically complex words and lexical access. *Linguistics, 23*, 759-774.

Seidenberg, M.S., & McClelland, J.L. (1989). A distributed, developmental model of word recognition and naming. *Psychological Review, 96*, 523-568.

Seidenberg, M.S., Plaut, D.C., Peterson, A.S., McClelland, J.L., & McCrae, K. (1994). Pronunciation and models of word recognition. *Journal of Experimental Psychology: Human Perception and Performance, 20*, 1177-1196.

Sénéchal, M. (2000). Morphological effects in children's spelling of French words. *Canadian Journal of Experimental Psychology 54, 2*, 76-85.

Seymour, P.H.K. (1997). Foundations of orthographic development. In C.A.Perfetti, L. Rieben, & M. Fayol (Eds.) *Learning to Spell: Research, Theory, and Practice Across Languages* (pp. 319-337). Mahwah, NJ: Lawrence Erlbaum Associates.

Seymour, P.H.K., & Evans, H.M. (1988). Developmental arrest at the logographic stage: Impaired literacy functions in Klinefelter's XXXY syndrome. *Journal of Research in Reading, 11*, 133-151.

Seymour, P.H.K., & Evans, H.M. (1994b). Levels of phonological awareness and learning to read. *Reading and Writing: An Interdisciplinary Journal, 6*, 221-250.

Shallice, T., & McCarthy, R. (1985). Phonological reading: From patterns of impairment to possible procedures. In M. Coltheart, K. Patterson, & J.C. Marshall (Eds.), *Deep Dyslexia*. London: Routledge & Kegan Paul.

Shallice, T., Warrington, E.K., & McCarthy, R. (1983). Reading without semantics. *Quarterly Journal of Experimental Psychology, 35A*, 111-138.

Shankweiler, D., & Crain, S. (1986). Language mechanisms and reading disorder: A modular approach. *Cognition. Special Issue: The onset of literacy, 24, 1-2*, 139-168.

Shankweiler, D., Crain, S., Brady, S., & Macaruso, P. (1992). .Identifying the causes of reading disability. In Gough, P. B., Ehri, L. C. (Eds.), *Reading acquisition* (pp 275-305). Hillsdale, NJ: Lawrence Erlbaum Associates.

Shankweiler, D., Smith, S.T., & Mann, V.A. (1984). Repetition and comprehension of spoken sentences by reading-disabled children. *Brain and Language, 23*, 241-257.

Shankweiler, D; Crain, S; Katz, L; Fowler, A E, Liberman, A.M. Brady, S.A., Thornton, R., Lundquist, E., Dreyer, L., Fletcher, J.M., Stuebing, K.K., Shaywitz, S.E., & Shaywitz, B.A. (1995). Cognitive profiles of reading-disabled children: Comparison of language skills in phonology, morphology, and syntax. *Psychological Science, 6, 3,* 149-156.

Share, D.L. (1995). Phonological recoding and self-teaching: Sine qua non of reading acquisition. *Cognition, 55*, 151-218.

Share, D.L. Jorm, A.F., MacLean, R., & Matthews, R. (2002). Temporal processing and reading disability. *Reading and Writing: An Interdisciplinary Journal, 15*, 151-178.

Shaughnessy, M. (1977). *Errors and expectations.* New York: Oxford University Press.

Shaywitz, S.E., Shaywitz, B.A., Pugh, K.R., Fulbright, R.K., Constable, R.T., Mencl, W.E., et al. (1998). Functional disruption in the organisation of the brain for reading in dyslexia. *Proceedings of the Natural Accademy of Science USA, 95*, 2636-2641.

Shaywitz, S.E., Shaywitz, B.A., Pugh, K.R., Mencl, W.E., Fulbright, R.K., Skudlarski, P., et al. (2002). Disruption of posterior brain systems for reading in children with developmental dyslexia. *Biological Psychiatry, 52*, 101-110.

Siegel, L. S. (1998). Phonological processing deficits and reading disabilities. In J. Metsala. & Ehri, L. C. (Eds), *Word recognition in beginning literacy.* Mahwah, NJ: Lawrence Erlbaum Associates

Siegel, L. S., & Ryan, E. B. (1988). Development of grammatical-sensitivity, phonological, and short-term memory skills in normally achieving and learning disabled children. *Developmental Psychology, 24, 1,* 28-37.

Siegel, L.S., Share, D., & Geva, E. (1995). Evidence for superior orthographic skills in dyslexics. *Psychological Science, 6, 4,* 250-254.

Singson, M., Mahony, D., & Mann, V. (2000). The relationship between reading ability and morphological skills: Evidence from derivational suffixes. *Reading and Writing: An Interdisciplinary Journal, 12,* 219-253.

Skottun, B.C. (2000). The magnocellular deficit theory of dyslexia: The evidence from contrast sensitivity. *Vision Research, 40,* 111-127.

Smith, S. T., Macaruso, P., Shankweiler, D., & Crain, S. (1989). Syntactic comprehension in young poor readers. *Applied Psycholinguistics, 10, 4,* 429-454.

Smith-Lock, K.M. (1991). Errors of inflection in the writing of normal and poor readers. *Language and Speech, 34, 4,* 341-350.

Snowling, M.J. (1981). Phoneme deficits in developmental dyslexia. *Psychological Research, 43,* 219-234.

Snowling, M.J. (1987). *Dyslexia: A cognitive developmental perspective.* Oxford: Blackwell.

Snowling, M. (1994). Towards a model of spelling acquisition: The development of some component skills. In G. Brown & N. Ellis (Eds.), *Handbook of spelling* (pp. 111-128). Chichester, UK: J. Wiley & Sons.

Snowling, M., (1995). Phonological processing and developmental dyslexia. *Journal of Research in Reading, 18,* 132-138.

Snowling, M. J. (2001). From language to reading and dyslexia. *Dyslexia 7,* 37-46.

Snowling, M.J., Bryant, P., & Hulme, C. (1993). Theoretical and methodological pitfalls in making comparisons between developmental and acquired dyslexia: Some comments on A. Castles & M. Coltheart. *Reading & Writing: An Interdisciplinary Journal, 8, 5*, 443-451.

Snowling, M.J., & Frith, U. (1981). The use of sound, shape and orthographic cues in early reading. *British Journal of Psychology, 72*, 83-88.

Snowling, M., & Hulme, C. (1989). A longitudinal case study of developmental phonological dyslexia. *Cognitive Neuropsychology*, 6, 379-403.

Snowling, M., Hulme, C., Wells, B., & Goulandris, N. (1992). Continuities between speech and spelling in a case of developmental dyslexia. *Reading & Writing: An Interdisciplinary Journal, 4, 1*, 19-31.

Snowling, M., Stackhouse, J., & Rack, J. (1986). Phonological dyslexia and dysgraphia: A developmental analysis. *Cognitive Neuropsychology, 3*, 309-339.

Snowling, M., Van Wagtendonk, B., & Stafford, C. (1988). Object-naming deficits in developmental dyslexia. *Journal of Research in Reading, 11*, 67-85.

Sprenger-Charolles, L., Siegel, L.S., & Béchennec, D. (1997). Beginning reading and spelling acquisition in French: a longitudinal study. In C.A.Perfetti, L. Rieben, & M. Fayol (Eds.), *Learning to Spell: Research, Theory, and Practice Across Languages* (pp. 339-359). Mahwah, NJ: Lawrence Erlbaum Associates.

Stackhouse, J. & Wells, B. (1997). How do speech and language problems affect literacy development? In C. Hulme, & M. Snowling (Eds.), *Dyslexia: Biology, Cognition, and Intervention* (pp. 59-71). London: Whurr.

Stage, S.A., & Wagner, R.K. (1992). The development of young children's phonological and orthographic knowledge as revealed by their spellings. *Developmental Psychology, 28*, 287-296.

Stanley, G. (1975). Two part stimulus integration and specific reading disability. *Perceptual and Motor Skills, 41,* 873-4.

Stanners, R.F., Neiser, J.J., Harmon, W.P., & Hall, R. (1979). Morphological structure and its effects on visual word recognition. *Journal of Verbal Learning and Verbal Behaviour, 8,* 399-412.

Stanovich, K.E. (1991). Discrepancy definitions of reading disability: Has intelligence led us astray? *Journal of Learning Disability, 21, 10,* 590-604.

Stanovich, K.E., & Siegel, L.S. (1994). The phenotypic performance profile of reading-diabled children: A regression based test of the phonological-core variable-difference model. *Journal of Educational Psychology, 86,* 1-30.

Stanovich, K., Siegel, L., & Gottardo, A. (1997a). Coverging evidence for phonological and surface subtypes of reading disability. *Journal of Educational Psychology, 89,* 860-869.

Stanovich, K. E., Siegel, L.S., & Gottardo, A. (1997b). Progress in the search for dyslexia subtypes. In C. Hulme & M. Snowling (Eds.) *Dyslexia: Biology, Cognition, and Intervention* (pp. 108-130). London: Whurr.

Stanovich, K.E. & West, R.F. (1989). Exposure to print and orthographic processing. *Reading Research Quarterly, 24,* 402-433.

Stein, C. L., Cairns, H. S., & Zurif, E. B. (1984). Sentence comprehension limitations related to syntactic deficits in reading-disabled children. *Applied Psycholinguistics, 5, 4,* 305-332.

Stein, J.F. (2001). The magnocellular theory of developmental dyslexia, *Dyslexia,* 7, 12-36.

Stein, J.F. & Fowler, M.S. (1993). Unstable binocular control in dyslexic children. *Journal of Research in Reading, 16,* 30-45.

Stein, J. F., & McAnally, K.I. (1996). Impaired auditory temporal processing in dyslexics. *Irish Journal of Psychology, 16*, 220-228.

Stein, J. F., Richarson, A.J., & Fowler, M.S. (2000b). Monocular occlusion can improve binocular control and reading in developmental dyslexics. *Brain, 1*, 2-3.

Stein, J.F. & Walsh, V. (1997). To see but not to read; the magnocellular theory of dyslexia. *Trends in Neuroscience, 20*, 147-152.

Sternberger, J.P., & MacWhinney, B. (1986). Frequency and the lexical storage of regularly inflected forms. *Memory and Cognition, 14*, 17-26.

Stoodley, C.J., Talcott, J.B., Carter, E.L., Witton, C., & Stein, J.F. (2000). Selective deficits of vibrotactile sensitivity in dyslexic readers. *Neuroscience Letters, 295*, 13-16.

Stuart, M. & Howard, D. (1995). KJ: A developmental deep dyslexic. *Cognitive Neuropsychology, 12*, 793-824.

Swanson, H.L. (1984). Semantic and visual memory codes in learning disabled readers. *Journal of Experimental Psychology, 37*, 124-140.

Taft, M. (1979). Recognition of affixed words and the word frequency effect. *Memory and Cognition, 7*, 263-272.

Taft, M. (1991). *Reading and the mental lexicon.* Hove, UK: Lawrence Erlbaum Associates.

Taft, M., & Forster, K.L. (1975). Lexical storage and the retrieval of prefixed words. *Journal of Verbal Learning and Verbal Behaviour, 14*, 638-647.

Taft, M. & Zhu, X. (1995). The representation of bound morphemes in the lexicon: A Chinese study. In L.B. Feldman (Ed.), *Morphological aspects of language processing* (pp 293-316). Hillsdale, NJ: Lawrence Erlbaum Associates.

Tager-Flusberg, H. (1997). Putting words together: morphology and syntax in the preschool years. In J. Berko Gleason (Ed.), *The Development of Language*. Allyn Bacon: NY.

Tainturier, M-J. & Rapp, B. (2001). The Spelling Process. In B. Rapp (Ed.), *The handbook of cognitive neuropsychology: What deficits reveal about the human mind* (pp. 263-289). Philadelphia: Psychology Press.

Tallal, P. (1980). Auditory temporal perception, phonics, and reading disabilities in children. *Brain and Language, 9*, 182-198.

Tallal, P. (1984). Temporal or phonetic processing deficit in dyslexia? That is the question. *Applied Psycholinguistics, 5*, 13-24.

Tallal, P., Miller, S., & Fitch, R. (1993). Neurobiological basis of speech: A case for the pre-eminence of temporal processing. *Annals of the New York Academy of Sciences, 682*, 27-47.

Temple, C. M. (1984a). Developmental analogues to acquired phonological dyslexia. In R.N. Malatasha & H.A. Whitaker (Eds.), *Dyslexia: A global issue*. (pp. 143-158). The Hague: Nijhoff.

Temple, C. M. (1984b). New approaches to the developmental dyslexias. In C. Rose (Ed.), *Progress in aphasiology* (pp. 223-232). London: Plenum Press.

Temple, C. M. (1985b). Reading with partial phonology. *Journal of Psycholinguistic Research, 14*, 523-541.

Temple, C. M. (1990c). Foop is still floop: A six year follow-up of phonological dyslexia and dysgraphia. *Reading and Writing: An Interdisciplinary Journal, 2*, 209-221.

Temple, C. M. (1997). *Developmental Cognitive Neuropsychology*. Hove: Lawrence Erlbaum Associates.

Temple, C. M., & Marshall, J.C. (1983). A case study of developmental phonological dyslexia. *British Journal of Psychology, 74*, 517-533.

Temple, E., Poldrack, R.A., Salidis, J., Deutsch, G.K., Tallal, P., Merzenich, M.M., et al. (2001). Disrupted neural responses to phonological and orthographic processing in dyslexic children: an fMRI study. *Neuroreport, 12*, 299-307.

Templeton, S., & Scarborough-Franks, L. (1985). The spelling's the thing: Knowledge of derivational morphology in orthography and phonology among older students. *Applied Psycholinguistics, 6*, 371-390.

Thompson, M.E. (1982). The assessment of children with specific reading difficulties (dyslexia) using the British Ability Scales. *British Journal of Psychology, 73*, 461-478.

Thompson, M.E. (1990). *Developmental Dyslexia: It's nature, assessment and remediation* (3rd Ed). Whurr.

Tornéus, M. (1984). Phonological awareness and reading: A chicken and egg problem? *Journal of Educational Psychology, 76*, 402-433.

Tornéus, M. (1987). The importance of metaphonological and metamorphological abilities for different phases of reading development. Paper presented at the Third World Congress of Dyslexia, Crete.

Totereau, C., Barrouillet, P., & Fayol, M. (1998). Overgeneralizations of number inflections in the learning of written French: The case of noun and verb. *British Journal of Developmental Psychology, 16, 4*, 447-464.

Totereau, C., Thevenin, M.G., & Fayol, M. (1997). The development of the understanding of number morphology in written French. In C.A.Perfetti, L. Rieben, & M. Fayol (Eds.), *Learning to Spell: Research, Theory, and Practice Across Languages.* (pp. 97-114). Mahwah, NJ: Lawrence Erlbaum Associates.

Treiman, R. (1992). The role of intrasyllabic units in learning to read and spell. In P.B. Gough, L.C. Ehri, & R. Treiman (Eds.), *Reading acquisition* (pp 65 – 106). Hillsdale, NJ: Lawrence Erlbaum Associates.

Treiman, R. (1993). Beginning to spell: A study of first-grade children. New York: Oxford University Press.

Treiman, R. (1994). Use of consonant letter names in beginning spelling. *Developmental Psychology, 30*, 567-580.

Treiman, R. (1997). Spelling in normal children and dyslexics. In B. A. Blachman (Ed.), *Foundations of reading acquisition and dyslexia: Implications for early intervention* (pp. 191-218). Mahwah, NJ: Lawrence Erlbaum Associates.

Treiman, R. & Baron, J. (1981). Segmental analysis: Development and relation to reading ability. In G.C. MacKinnon & T.G. Waller (Eds.), *Reading research: Advances in theory and practice,* Vol III. New York: Academic Press.

Treiman, R. & Cassar, M. (1996). Effects of morphology on children's spelling of final consonant clusters. *Journal of Experimental Child Psychology, 63, 1,* 141-170.

Treiman, R. & Cassar, M. & Zukowski, A. (1994). What types of linguistic information do children use in spelling? The case of flaps. *Child Development, 65, 5,* 1318-1337.

Treiman, R., Kessler, B., & Bourassa, D. (2001). Children's own names influence their spelling. *Applied Psycholinguistics, 22,* 555-570.

Trussell, L. O. (1998). Cellular mechanisms for preservation of timing in central auditory pathways. *Current Opinion in Neurobiology*, *7*, 487-492.

Tulving, E., & Gold, C. (1963). Stimulus information and contextual information as determinants of tachistoscopic recognition of words. *Journal of Experimental Psychology, 66*, 319-327.

Tunmer, W. E. & Nesdale, A. R., & Wright, A. D. (1987). Syntactic awareness and reading acquisition. *British Journal of Developmental Psychology, 5, 1*, 25-34.

Tyler, L. (1992). *Spoken language comprehension: An experimental approach to disordered and normal processing.* Cambridge, MA: MIT Press.

Tyler, L., & Cobb, H. (1988). Processing of bound grammatical morphemes in context: The case of an aphasic patient. *Language and Cognitive Processes, 2*, 245-262.

Tyler, L., & Ostrin, R. (1994). The processing of simple and complex words in an agrammatic patient: Evidence from priming. *Neuropsychologia, 38,* 1001-1031.

Uhry, J., & Shepherd, J. (1993). Segmentation/spelling instruction as part of a first grade reading program: Effects on several measures of reading. *Reading Research Quarterly, 28,* 218-233.

Valdois, S., Bosse, M.L., Ans, B., Zorman, M., Carbonnel, S., David, D., & Pellat, J. (2003). Phonological and visual processing deficits are dissociated in developmental dyslexia: Evidence from two case studies. *Reading and Writing: An Interdisciplinary Journal 16 (6),* 541-572.

Van Daal, V., & Van der Leij, A. (1999). Developmental dyslexia: Related to specific or general deficits? *Annals of Dyslexia, 49*, 71-104.

Van der Leij, A., Lyytinen, H., & Zwarts, F. (2001). The study of infant cognitive processes in dyslexia. In A. Fawcett (Ed.), *Dyslexia: Theory and good practice.* (pp. 160-182). London: Whurr.

Van Orden, G.C. (1987). A ROWS is a ROSE: Spelling, sound and reading, *Memory and Cognition 15 (3),* 181-198.

Van Orden, G.C. (1991). Phonologic mediation is fundamental to reading. In D. Besner & G. W. Humprhreys (Eds.), *Basic processes in reading: Visual word recognition* (pp. 77-103). Hillsdale, NJ: Lawrence Erlbaum.

Van Orden, G.C., Pennington, B., & Stone, G.O. (1992). Word identification in reading and the promise of subsymbolic psycholinguistics. *Psychological Review, 47*, 488-522.

Victor, J.D., Conte, M.M., Burton, L., & Nass, R.D. (1993). Visual evoked potentials in dyslexics and normals: failure to find a difference in transient or steady-state responses. *Visual Neuroscience, 10*, 939-946.

Vogel, S.A. (1974). Syntactic abilities in normal and dyslexic children. *Journal of Learning Disabilities, 7*, 103-109.

Vogel, S. (1983). A qualitative analysis of morphological development in learning disabled and achieving children. *Journal of Learning Disabilities, 16*, 416-420.

Werker, J., & Tees, R. (1987). Speech perception in severely disabled and average reading children. *Canadian Journal of Psychology, 41*, 48-61.

Wiig, E. H., Semel, E.M., & Crouse, M, B. (1973). The use of English morphology by high-risk and learning disabled children. *Journal of Learning Disabilities, 6, 7*, 59-67.

Wilkinson, G.S. (1993). Wide Range Achievement Test 3. Wilmington (DE): Wide Range.

Willows, D.M., & Ryan, E.B. (1986). The development of grammatical sensitivity and its relation to early reading achievement. *Reading Research Quarterly, 21*, 253-266.

Wimmer, H. (1996). The nonword reading deficit in developmental dyslexia: Evidence from children learning to read German. *Journal of Experimental Child Psychology, 61, 1*, 80-90.

Wimmer, H., & Goswami, U. (1994). The influence of orthographic consistency on reading development: Word recognition in English and German children, *Cognition, 51*, 91-103.

Wimmer, H., Mayringer, H., & Landerl, K. (1998). Poor reading: A deficit in skill automatization or a phonological deficit? *Scientific Studies in Reading, 2*, 321-340.

Wise, B.W., Olson, R.K., & Treiman, R. (1990). Subsyllabic units as aids in beginning readers' word learning: Onset-rime versus post-vowel segmentation. *Journal of Experimental Child Psychology, 49*, 1-19.

Witton, C., Talcott, J.B., Hansen, P.C., Richardson, A.J., Griffiths, T.D., Rees, A., Stein, J.F., & Green, G.G.R. (1998). Sensitivity to dynamic auditory and visual stimuli predicts nonword reading ability in both dyslexic and normal readers. *Current Biology, 8*, 791-797.

Wolf, M. & Bowers, P. (1999). The 'double-deficit hypothesis' for the developmental dyslexias. *Journal of Educational Psychology, 91*, 1-24.

Wolf, M., & O'Brien, B. (2001). On issues of time, fluency and intervention. In A. Fawcett (Ed.), *Dyslexia: Theory and good practice* (pp. 124-140). London: Whurr.

Worden, P.E. & Boettcher, W. (1990). Young children's acquisition of alphabet knowledge. *Journal of Reading Behaviour, 22*, 277-295.

Worthy, J., & Viise, N.M. (1996). Morphological, phonological, and orthographic differences between the spelling of normally achieving children and basic literacy adults. *Reading and Writing: An Interdisciplinary Journal, 8, 2,* 129-159.

Yap, R. L., & Van der Leij, A. (1994). Testing the automatization deficit hypothesis of dyslexia via a dual-task paradigm. *Journal of Learning Disabilities, 27*, 660-665.

Yopp, H.K. (1988). The validity and reliability of phonemic awareness tests. *Reading Research Quarterly, 23,* 159-177.

Yule, W., Rutter, M., Berger, M., & Thompson, B. (1973). Over and under achievement in reading. *British Journal of Educational Psychology, 44,* 1-12.

Appendix A

Sentence Analogy task

Pilot study instructions: I am going to say a sentence, then another sentence. Listen to the change between the first and second sentence. I will then give you a sentence and I want you to change it in the same way that I changed my sentence. Let's have a practice.
1. John lifts the cup. John lifted the cup. John eats the food.
2. Pete climbed the ladder. Pete climbs the ladder. Pete cleaned the window.
3. Lisa writes a letter. Lisa wrote a letter. Lisa posts the letter.

Experiment 2 instructions: I have these toys: Bert and Sid. Bert is going to say a sentence, then Sid will say it again but change it in some way.

(Point to each toy as it's talking)

Bert says: Jane plays with the dolls.
Sid says: Jane played with the dolls.

Now Bert will say another sentence, and Sid will change it in the same way he did before.

Bert says: Jane washes the baby.
Sid says: Jane washed the baby.

Now, Sid has a sore throat and can't talk today, so can you help him and say the sentence for him? Shall we have a try?

1. Bert: John lifts the cup.
   Sid: John lifted the cup.
   Bert: John eats the food.

Now can you help Sid? What should he say? Sid should say (give child chance to respond) …John ate the food.

2. Bert: Pete climbed the ladder.
   Sid: Pete climbs the ladder.
   Bert: Pete cleaned the window.
   Sid: ___________________ (Pete cleans the window)

3. Bert: Lisa writes a letter.
   Sid: Lisa wrote a letter.
   Bert: Lisa posts the letter.
   Sid: ____________ (Lisa posted the letter)

Experimental items

	Item	Response
1.	Bert: Tom helps Mary. Sid: Tom helped Mary. Bert: Tom sees Mary. Sid: _____________ (Tom saw Mary)	
2.	Bert: Bob gives the ball to Anne. Sid: Bob gave the ball to Anne. Bert: Bob tells a story to Anne. Sid: __________________ (Bob told a story to Anne).	
3.	Bert: Jane threw the ball. Sid: Jane throws the ball. Bert: Jane kicked the ball. Sid: ___________________ (Jane kicks the ball).	
4.	Bert: I felt happy. Sid: I feel happy. Bert: I was ill. Sid: _________________ (I am ill)	
5.	Bert: The dog is scratching the chair. Sid: The dog scratched the chair. Bert: The dog is chasing the cat. Sid: _______________ (The dog chased the cat).	
6.	Bert: Bob is turning the television on. Sid: Bob turned the television on. Bert: Bob is plugging the kettle in. Sid: ______________ (Bob plugged the kettle in).	
7.	Bert: The cow woke up. Sid: The cow wakes up. Bert: The cow ran away. Sid: ________________ (The cow runs away).	
8.	Bert: She kept her toys in a box. Sid: She keeps her toys in a box. Bert: She hung her washing on a line. Sid: __________________ (She hangs her washing on the line).	

Appendix B1

Regular past tense and one-morpheme words used in the reading and spelling tasks in Experiment I (adapted from Treiman & Cassar, 1996).

	Regular past tense	Freq	Log Freq	Len.	No. phon	One-morpheme	Freq	Log Freq	Len	No. phon
1	tuned	65	1.81	5	4	brand	52	1.71	5	5
2	leaned	138	2.13	6	4	mound	58	1.76	5	4
3	loaned	22	1.34	6	4	blond	22	1.34	5	5
4	earned	104	2.01	6	3	hound	47	1.67	5	4
5	rained	49	1.69	6	4	blind	191	2.28	5	5
6	shared	117	2.06	6	4	beard	89	1.95	5	4
7	laced	15	1.17	5	4	arrest	23	1.36	6	5
8	faced	130	2.11	5	4	feast	103	2.01	5	4
9	raced	181	2.25	5	4	boast	18	1.25	5	4
10	kicked	85	1.92	6	4	collect	189	2.27	7	6
11	baked	93	1.968	5	4	elect	43	1.633	5	5
12	raked	18	1.25	5	4	connect	92	1.96	7	6
13	puffed	35	1.54	6	4	drift	74	1.86	5	5
14	killed*	443	2.65	6	4	child*	767	2.88	5	4
15	turned*	1784	3.25	6	4	friend*	944	2.97	6	5
16	covered**	844	2.92	7	5	third**	983	2.99	5	4
	MEAN	**257.68**	**2.0**	**5.7**	**4.0**		**230.93**	**1.9**	**5.37**	**4.68**

* Used in List A, Analysis 1; ** Used in reading task only

Appendix B2

Presentation of regular past tense and one-morpheme words for the reading task

kicked	shared	blind
killed	boast	beard
puffed	covered	brand
friend	raked	turned
collect	third	tuned
hound	leaned	rained
drift	mound	faced
baked	feast	connect
loaned	elect	earned
laced	blond	raced
child	arrest	

Appendix B3

Presentation of regular past tense words and one-morpheme words in the spelling task.

1.	baked	We **baked** a cake	baked
2.	leaned	He **leaned** on the table	leaned
3.	arrest	We **arrest** bad people	arrest
4.	hound	The **hound** was barking	hound
5.	feast	The **feast** was delicious	feast
6.	rained	It **rained** all day	rained
7.	puffed	She **puffed** and huffed	puffed
8.	brand	That **brand** is expensive	brand
9.	raced	We **raced** home	raced
10.	blond	The **blond** girl is pretty	blond
11.	shared	We **shared** some sweets	shared
12.	mound	The **mound** of rubbish is smelly	mound
13.	drift	I **drift** on the river	drift
14.	loaned	He **loaned** me money	loaned
15.	blind	The **blind** man tripped	blind
16.	raked	We **raked** the leaves	raked
17.	elect	I **elect** a leader	elect
18.	tuned	He **tuned** a guitar	tuned
19.	laced	We **laced** our shoes	laced
20.	beard	The **beard** is long	beard
21.	earned	We **earned** some money	earned
22.	faced	They **faced** each other	faced
23.	collect	I **collect** stickers	collect
24.	killed	I **killed** a fly	killed
25.	turned	I **turned** the corner	turned
26.	child	The **child** is skipping	child
27.	kicked	She **kicked** a ball	kicked
28.	connect	We **connect** our phone	connect
29.	friend	My **friend** is nice	friend
30.	boast	I **boast** about my dog	boast

Appendix C1

Words used for regular verb, irregular verb, and one-morpheme spelling test (List B, based on Nunes et al., 1997).

Reg past tense	Freq	Log Freq	Len	No. phon	Irregular past tense	Freq	Log Freq	Len	No. phon	One morph	Freq	Log Freq	Len	No. phon
called	5789	3.76	6	4	Told	2028	3.31	4	4	cold	1478	3.17	4	4
covered	844	2.92	7	5	Heard	1990	3.3	5	4	third	983	2.99	5	4
killed	443	2.65	6	4	Held	1049	3.02	4	4	child	767	2.88	5	4
filled	656	2.82	6	4	Sold	477	2.68	4	4	wild	973	2.99	4	4
turned	1784	3.25	6	4	Found	3365	3.53	5	4	friend	944	2.97	6	5
laughed	639	2.81	7	4	Left	2923	3.47	4	4	Soft	669	2.82	4	4
kissed	65	1.8	6	4	Lost	836	2.92	4	4	wrist	61	1.79	5	4
slipped	214	2.3	7	5	Slept	200	2.3	5	5	except	716	2.8	6	6
dressed	310	2.49	7	5	felt	1231	3.09	4	4	salt	530	2.72	4	4
stopped	1057	3.02	7	5	Sent	835	2.92	4	4	tent	208	2.13	4	4
MEAN	**1180.1**	**2.78**	**6.5**	**4.4**		**1493.4**	**3.05**	**4.3**	**4.1**		**626.66**	**2.56**	**4.83**	**4.41**
SD	**1692.4**	**0.53**	**0.52**	**0.51**		**1049.7**	**0.37**	**0.48**	**0.31**		**445.39**	**0.57**	**0.83**	**0.79**

Appendix C2

Presentation of regular verbs, irregular verbs, and one-morpheme words in spelling (List B, Experiment I).

1.	held	I **held** her hand	held
2.	cold	The **cold** weather is awful	cold
3.	felt	He **felt** unwell	felt
4.	third	The **third** child is a girl	third
5.	filled	I **filled** my glass	filled
6.	kissed	He **kissed** her cheek	kissed
7.	called	I **called** my friend	called
8.	covered	She **covered** her eyes	covered
9.	wrist	His **wrist** is broken	wrist
10.	told	She **told** some lies	told
11.	except	We like all **except** one	except
12.	turned	I **turned** the corner	turned
13.	sold	We **sold** the house	sold
14.	sent	I **sent** a letter	sent
15.	child	The **child** is skipping	child
16.	stopped	I **stopped** running	stopped
17.	left	We **left** the car	left
18.	lost	I **lost** my purse	lost
19.	wild	The **wild** flowers are blue	wild
20.	salt	The **salt** pot is broken	salt
21.	slipped	We **slipped** on ice	slipped
22.	laughed	We **laughed** out loud	laughed
23.	found	I **found** my way	found
24.	soft	A **soft** jumper is best	soft
25.	tent	The **tent** was big	tent
26.	slept	I **slept** all night	slept
27.	heard	We **heard** a noise	heard
28.	dressed	He **dressed** in blue	dressed
29.	killed	I **killed** a fly	killed
30.	friend	My **friend** is nice	friend

Appendix D1

Regular, irregular, and non-words used in Experiment 2

Regular						Irregular					
	Freq	Log freq	img	No. phon	No. lett		Freq	Log freq	img	No. phon	No. Lett
1. part	4285	3.6	340	3	4	work	4363	3.63	458	3	4
2. help	3875	3.58	464	4	4	give	3369	3.52	383	3	4
3. fresh	573	2.75	453	4	5	island	820	2.91	643	5	6
4. stop	1091	3.03	452	4	4	iron	838	2.9	561	3	4
5. card	223	2.34	578	4	4	shoe	148	2.17	601	2	4
6. tent	208	2.31	593	4	4	lamb	287	2.45	641	3	4
7. trunk	186	2.44	593	5	5	ghost	171	2.23	505	4	5
8. frog	176	2.24	617	4	4	wolf	179	2.25	610	4	4
9. chin	138	2.13	604	3	4	palm	122	2.08	555	3	4
10. nerve	121	2.08	486	3	5	wrist	61	1.7	-	4	5
11. shelf	150	2.17	-	4	5	sword	95	1.97	444	3	5
12. snap	69	1.83	-	4	4	bomb	60	1.77	606	3	4
13. smog	22	1.34	-	4	4	cough	30	1.477	-	3	5
14. dentist	42	1.6	622	7	7	bouquet	13	1.1	599	4	7
15. radish	14	1.14	-	6	6	regime	17	1.20	-	5	6
16. marathon	8	0.9	-	7	8	meringue	9	0.95	-	5	8
MEAN	**736.2**			**4.44**	**4.81**					**3.5**	**4.9**
SD	**1387.92**			**1.20**	**1.22**					**0.89**	**1.24**

Non-words				
Regular Match	Irregular match	Non-word	No. phonemes	No. letters
dentist	bouquet	bantost	7	7
nerve	wrist	torve	3	5
chin	palm	drim	4	4
tent	lamb	fent	4	4
smog	cough	fleg	4	4
marathon	meringue	golthom	6	7
frog	wolf	krog	4	4
help	give	melp	4	4
part	work	nart	3	4
trunk	ghost	nost	4	4
card	shoe	plard	4	5
fresh	island	plish	4	5
shelf	sword	quard	4	5
radish	regime	retash	5	6
snap	bomb	snom	4	4
stop	iron	trup	4	4

Appendix D2

Presentation of regular and irregular word reading list

work	shelf	bouquet
part	dentist	ghost
snap	stop	iron
wolf	nerve	shoe
give	fresh	smog
land	island	tent
sword	radish	palm
regime	trunk	cough
frog	meringue	wrist
card	bomb	marathon
help	chin	

Presentation of non-word reading list

nart	drim	nost
krog	torve	bantost
melp	fleg	golthom
turp	plish	fent
plard	snom	retash
quard		

Appendix D3

Regular word and irregular word spelling task

1. lamb	lamb	lamb
2. snap	snap	snap
3. frog	frog	frog
4. meringue	meringue	meringue
5. nerve	nerve	nerve
6. shoe	shoe	shoe
7. smog	smog	smog
8. shelf	shelf	shelf
9. cough	cough	cough
10. palm	palm	palm
11. part	part	part
12. stop	stop	stop
13. help	help	help
14. radish	radish	radish
15. chin	chin	chin
16. dentist	dentist	dentist
17. wolf	wolf	wolf
18. sword (as in sword used by solder)	sword	sword
19. regime	regime	regime
20. ghost	ghost	ghost
21. iron	iron	iron
22. bomb	bomb	bomb
23. bouquet	bouquet	bouquet
24. fresh	fresh	fresh
25. card	card	card
26. trunk	trunk	trunk
27. work	work	work
28. give	give	give
29. wrist	wrist	wrist
30. tent	tent	tent
31. marathon	marathon	marathon
32. island (as in desert)	island	island

Non-word spelling task

Practice 1. Sith (pith)	*Sith (pith)*	*Sith (pith)*
Practice 2. Grop (crop)	*Grop (crop)*	*Grop (crop)*
1. nart (cart)	nart (cart)	nart (cart)
2. plard (card)	plard (card)	plard (card)
3. melp (help)	melp (help)	melp (help)
4. fleg (peg)	fleg (peg)	fleg (peg)
5. golthom (gol-thom)	golthom (gol-thom)	golthom (gol-thom)
6. plish (fish)	plish (fish)	plish (fish)
7. quard (lard)	quard (lard)	quard (lard)
8. snom (from)	snom (from)	snom (from)
9. trup (cup)	trup (cup)	trup (cup)
10. retash (re-hash)	retash (re-hash)	retash (re-hash)
11. torve (torv)	torve (torv)	torve (torv)
12. nost (cost)	nost (cost)	nost (cost)
13. krog (frog)	krog (frog)	krog (frog)
14. fent (went)	fent (went)	fent (went)
15. drim (dim)	drim (dim)	drim (dim)
16. bantost (ban-tossed)	bantost (ban-tossed)	bantost (ban-tossed)

Appendix E

Phoneme Deletion

Instructions: Now, I want you to think about how a word is made up of different sounds. Listen to me say ‘panda’. Now you say ‘panda’ without the ‘da’. (If necessary prompt with pan – da). OK, let’s do some more.

Practice items

Say rainbow	Say it again, without /bow/
Say stake	Say it again, without the /st/
Say cat	Sat it again, without the /c/

	Experimental items		RESPONSE (if wrong, put in what child said)
3	Say blind	Say it again , without the /b/	
4	Say drift	Say it again, without the /d/	
7	Say shelf	Say it again, without the /f/	
9	Say radish	Say it again, without the /d/	
2	Say soft	Say it again, without the /s/	
5	Say mound	Say it again, without the /d/	
1	Say help	Say it again, without the /h/	
6	Say trunk	Say it again, without the /k/	
10	Say connect	Say it again, without the /n/	
12	Say friend	Say it again, without the /n/	
11	Say feast	Say it again, without the /s/	
8	Say boast	Say it again, without the /t/	

Appendix F

Nonword repetition

Instructions: I am going to say some nonsense words, and I want you to repeat them after me. Shall we have a practice?

Stop testing when the child makes 2 consecutive mistakes.

Practice Items

1. Teg
2. Ballop
3. Fepgolthom

Experimental items

Nonword	Syllables	Response
Tafflest	2	
Pennel	2	
Barrazon	3	
Thickery	3	
Penneriful	4	
Emplifovent	4	
Confrantually	5	
Detratapillic	5	
Brasteryskiticult	6	
Trumpetinetrosterer	6	
Loppenapishstopograt	7	
Woogalamisperplister	7	

Appendix G

Digit span

Instructions: Now, I am going to say some numbers and I want you to repeat them as I said them. Let's have a practice first.

Practice items

37

241

Experimental items

361
482

5829
3147

83926
17318

269473
618275

8394172
7925731

93582417
52948173

695317284
517829468

Appendix H

Inflecting nonsense words

Instructions: I am going to show you some pictures and say some sentences about the pictures and I want you to tell me the missing word. Shall we have a practice?

	Practice items
1.	*This is a* ***zug****. Now there is another one. There are two of them. There are two __________ (zugs).*
2.	*This is a man who knows how to* ***gutch****. He is gutching. He does it every day. Every day he ______ (gutches)*
3.	*This is a girl who knows how to* ***tron****. She is tronning. She did it yesterday. What did she do yesterday? Yesterday she _________ tronned)*
	Experimental items
1.	This is a man who knows how to **guck**. He is **gucking**. He did the same thing yesterday. What did he do yesterday? Yesterday he _________ (gucked).
2.	This is a girl who knows how to **zon**. She is **zoning**. She did the same thing yesterday. What did she do yesterday? Yesterday she ___________ (zonned).
3.	This is a girl who knows how to **slown.** She is **slowning**. She did the same thing yesterday. What did she do yesterday? Yesterday she ___________ (slowned).
4.	This is a man who knows how to **gling.** He is glinging. He does it every day. Every day he _________ (glings).
5.	This is a boy who knows how to **chur.**. He is **churring**. He did the same thing yesterday. What did he do yesterday? Yesterday she ___________ (churred).
6.	This is a **tor**. Now there is another one. There are two of them. There are two __________ (tors).
7.	This is a girl who knows how to **zoll.**. She is **zolling**. She did the same thing yesterday. What did she do yesterday? Yesterday she ___________ (zolled).
8.	This is a man who knows how to **nace. He** is **nacing**. He did the same thing yesterday. What did he do yesterday? Yesterday, he _______ (naced).
9.	This is a girl who can **nizz.** She is **nizzing**. She does it every day. Every day she _____________ (nizzes).
10.	This is a boy who can **woss.** He is **wossing**. He did the same thing yesterday. What did he do yesterday? Yesterday he _________ (wossed).
11.	This is a man who can **meck. He** is **mecking. He** did the same thing yesterday. What did he do yesterday? Yesterday he _______ mecked).

Appendix I

Morphological judgement

Instructions: Now, I want you to think about how a word is made up of other words. Listen to me say 'walked'. Can you think of a smaller word in 'walked' that means something like 'walked'? What would it be? (give child time to respond). It would be 'walk'. Shall we try some more?
Note: if child says 'yes' to a question, ask them to supply the word.

	Practice items
1	Is there a smaller word in **chair** that means something like **chair**?
2	Is there a smaller word in **twisted** that means something like **twisted**?

OK, do you see what to do now? Let's do some more, but I can't help you with these.

	Experimental items
5	Is there a smaller word in **dressed** that means something like **dressed**?
3	Is there a smaller word in **kissed** that means something like **kissed**?
9	Is there a smaller word in **beard** that means something like **beard**?
7	Is there a smaller word in **tent** that means something like **tent**?
11	Is there a smaller word in **collect** that means something like **collect**?
2	Is there a smaller word in **baked** that means something like **baked**?
8	Is there a smaller word in **card** that means something like **card**?
1	Is there a smaller word in **leaned** that means something like **leaned**?
6	Is there a smaller word in **filled** that means something like **filled**?
10	Is there a smaller word in **blood** that means something like **blood**?
12	Is there a smaller word in **boast** that means something like **boast**?
4	Is there a smaller word in **shared** that means something like **shared**?

Appendix J

Non-words in sentence context task used in Experiment 4

Note. Filler items are in italics and were administered to adults only.

List A

Practice 1. Jinked (winked)	*He **jinked** the money*	*jinked*
Practice 2. Plost (cost)	*The **plost** is nice*	*plost*
1. slound (found)	Our **slound** was heavy	slound
2. mecked (wrecked)	He **mecked** his violin	mecked
3. schloss	*I schloss the list*	*schloss*
4. gucked (ducked)	He **gucked** his paper	gucked
5. floop	*The floop was happy*	*floop*
6. fuffed (cuffed)	We **fuffed** our shoes	fuffed
7. tissed (kissed)	He **tissed** my baby	tissed
8. nand (hand)	The **nand** was big	nand
9. kring	*The kring was crying*	*kring*
10. naste (paste)	The **naste** is laughing	naste
11. grong	*The grong is loud*	*grong*
12. lund (fund)	A **lund** is singing	lund
13. krolled (rolled)	We **krolled** his cat	krolled
14. prut	*The prut is silly*	*prut*
15. churd (heard)	The **churd** was red	churd
16. wost (cost)	A **wost** is funny	wost
17. lunk	*The lunk was mad*	*lunk*
18. vacked (whacked)	He **vacked** our door	vacked
19. brift	*You brift the child*	*brift*
20. zond (pond)	A **zond** is wet	zond
21. plurred (purred)	We **plurred** the animals	plurred
22. plicks	*He plicks the word*	*plicks*
23. trond (pond)	The **trond** was hopping	trond
24. vrup	*I vrup the window*	*vrup*

List B

Practice 1. blicked (licked)	*He blicked the road*	*blicked*
Practice 2. jope (hope)	*The jope is blue*	*jope*
1. guct (duct)	A **guct** was clever	guct
2. grong	*I grong the orange*	*grong*
3. lunned (fund)	I **lunned** the ball	lunned
4. slowned (frowned)	I **slowned** the dishes	slowned
5. tronned (pond)	She **tronned** the book	tronned
6. prut	*We prut the table*	*prut*
7. nanned (canned)	I **nanned** the dog	nanned
8. vrup	*The vrup has wings*	*vrup*
9. tist (fist)	A **tist** was dancing	tist
10. plicks	*The plicks is hard*	*plicks*
11. mect (sect)	The **mect** is flying	mect
12. churred (furred)	She **churred** her dinner	churred
13. brift	*The brift is grey*	*brift*
14. krold (cold)	The **krold** is playing	krold
15. plurd (curd)	The **plurd** is blue	plurd
16. lunk	*They lunk the bread*	*lunk*
17. kring	*I kring the people*	*kring*
18. wossed (tossed)	She **wossed** the garden	wossed
19. schloss	*A schloss has fun*	*schloss*
20. zonned (pond)	I **zonned** my cake	zonned
21. vact (fact)	The **vact** was crying	vact
22. floop	*We floop the paper*	*floop*
23. fuft (tuft)	Our **fuft** is broken	fuft
24. naced (raced)	She **naced** my sweets	naced

Appendix K

	AB			**MB**			**MB**			**JG**		
	initial 21.1.02	midway 25.2.02	final 8.4.02	initial 21.1.02	midway 25.2.02	final 8.4.02	initial 23.1.02	midway 27.2.02	final 6.3.02	initial 23.1.02	midway 27.2.02	final 6.3.02
called	\	\	\	\	\	\	\	\	\	caled	caled	\
covered	coverd	coverd	coverd	coved	coved	coved	covd	cufed	cuvud	cuvued	cuvued	cuvud
killed	cild	\	\	\	\	\	kild	kild	\	kiled	kiled	kild
filled	thild	\	\	fild	fild	fild	fild	fild	fild	filed	filed	fild
turned	trand	turd	turnd	tand	tanrd	turn	turnd	turnd	\	terned	terned	ternd
laughed	larther	lath	laugth	laft	laft	laft	laft	laft	laft	larft	larft	larft
kissed	kiss	kist	\	kiss	kist	kisst	\	kist	\	kised	kised	kisst
slipped	slipt	slipt	slipt	slipt	slipt	slipt	slipt	slipt	slipt	sliped	sliped	slipt
dressed	drest	drest	drest	dresst	drest	drest	drest	drest	\	drest	dresed	drest
stopped	\	stopt	stop	stop	stopt	stoped	stoped	stopd	stopd	stoped	stoped	\
told	\	\	\	\	\	\	\	\	\	toled	toled	toled
heard	herd	herd	herd	herd	herd	herd	hered	hered	hered	herd	herd	herd
held	\	\	\	\	\	\	\	\	\	heled	\	\
sold	\	\	\	\	\	\	\	\	\	soled	soled	\
found	fand	fond	fond	fawnd	fawnd	fond	\	fond	fowned	founed	founed	fawnd
left	\	\	\	\	\	\	\	\	\	lefed	lefed	\
lost	\	\	\	\	\	\	\	\	\	losed	losed	\
slept	\	\	\	sleept	sleept	sleeped	sleped	\	sleped	sleped	sleped	sleped
felt	thelt	\	\	\	\	\	\	\	\	\	\	\
sent	\	\	\	\	\	\	\	\	\	sened	sened	\
cold	\	\	\	\	\	\	\	\	\	cowled	cowled	\
third	therd	therd	\	theerd	thurd	\	fierd	third	thered	thered	thurd	\
child	\	\	\	chlod	chiled	\	chiled	chiled	chiled	chialed	chialed	chiled
wild	wiled	willed	\	\	\	\	\	\	\	wioled	\	\
friend	frind	frened	friend	\	\	\	frend	frend	frened	frened	freined	frend
soft	\	\	\	\	\	\	sfot	sofed	\	sofed	sofed	\
wrist	rist	rist	rist	rist	rist	rist	rist	rist	rist	rissed	rist	rist
except	espt	exsept	esxpet	exsept	esxept	exsept	exept	exept	exept	exsepped	exseped	exept
salt	solt	solt	solt	solt	solt	\	solt	solt	solt	solt	solt	\
tent	\	\	\	\	\	\	\	\	\	\	\	\

Appendix L

Passage dictation task from case studies

I felt tired so I slept in late today. I went into the bathroom and found my little sister had splashed water all over the bathroom floor. When I went in I slipped over. My sister laughed. I could have killed her. I nearly lost my temper but I held my breath and counted to ten. I told mum and she sent her downstairs. I covered the floor with a towel and turned on the taps, filled the sink, and washed my face. I got dressed quickly. I heard mum. 'Come on,' she called. After breakfast, I stopped by the mirror and brushed my hair with the brush Jane sold me. I kissed mum goodbye, left the house and walked to school.

AB
I felt tird so I slept in late to day. I went in to the Bathroon and fond little sister and my litte sister splast water all over the Bathroom floor I slipt over and she lath I caud of killed her. I niley lost my temper But I held my Brefh and canted to ten I told mum how senter downstars I coverd the floor witl a tault, curd on the cops, fild the sink and wast my face. I got grest cwictey. I hererd my mum come on she called. after brefast I stop buy the miror and brust my hear with the brush the brush Jan sold my I kisst mum. She sent me and I left the howse and walke to school.

MD
I felt tied so I sleept in today. I went into to bathroom and fawnd sister and she splash wort ut on the bathroom Flor and laft I cade of killed her. I ninl lost my temp but I held my bref and conut to ten I told mum hosent her downsters. I coved the floor with a tawl, tard on the taps, and fild the sinck and wash my face. I got drest cwicly. I herd my mum came she cold. after breckfst I stoppt by the mirre and brusht my heair with the brush Jane sald me. I kisst mum left the and workd to school.

MB
I felt tiard so I slept in. I went into the Bathroom and fond my litel sister had splast warter all ofeer the bathroom flor wehen I went in I slipet over she laft I cold of kild her I nerly lost my tempe But I helt my breth and conted to ten. I told mum and see seter her Downsters I cowred the flor with a towl ternd on the taps fild the sink and wast my fase. I got drest quicle I hered my mum comon see cold after Brecfast I stoped By the mirei and Brusht my hear with the Brus jane sold me. I kiset mum god Bye left the hous and walked to skcool.

JG

I felt tiaed so I slept in late today. I went into the barthroom and fawnd my ltter sitter had splasht watter all over the darthrood flor when I went in I splipt over. she larft I culd have cilled her I nele lost my temper but I held my dreth and countid to ten. I toled mum and she sent he down slares. I cuvad the flor with a towle, ternd on the taps, filled the sinck and washed my face. I got drest quikle. I herd my mum cum on she cauld arfer drecfast I stoped dy the mirer and drushed my har with the drush gane soled me. I kist mum godciy, left the house and warked to school.

Appendix M

Case study spellings of regular past tense verbs and one-morpheme words (List A)

Target	AB	MD	JG	MB
tuned	chund	tuoond	choned	tond
leaned	lend	lerd	leened	laend
loaned	lond	lond	loned	lond
earned	urnd	and	erned	ernd
rained	\	rande	rained	rand
shared	sherd	sherd	fard	sherd
laced	last	last	\	last
faced	fast	\	faised	fast
raced	rast	race	raist	rast
kicked	kict	kick	kiked	kicd
baked	\	baick	baiked	backed
raked	ract	\	raiked	\
puffed	pufft	puft	puft	puft
brand	braned	\	\	\
mound	mownd	mand	\	mond
blond	\	\	bloned	\
hound	hownd	hawnd	\	hownd
blind	\	bland	blighed	\
beard	\	beder	bered	berd
arrest	\	arest	uresed	arest
feast	\	fest	feesed	feest
boast	bost	bost	bosed	bost
collect	clect	clecd	culeked	clot
elect	\	elecd	ileced	\
connect	cnect	knend	cuneced	conet
drift	\	drifd	\	dift

Appendix N

Case study reading errors on regular past tense verbs and one-morpheme words (List A)

Target	AB	MD	MB	JG
tuned	\	turned	turned	tonned
leaned	learned	led	lend	\
loaned	\	\	luned	\
earned	\	und	ern-ed	\
rained	\	\	rand	\
shared	\	\	shard	shard
laced	\	let	lonset	lacked
faced	fenced	\	feast	\
raced	\	race	rancid	\
kicked	\	\	\	\
baked	blanked	breaked	back-ed	\
raked	record	ris	racked	racked
puffed	\	\	\	\
killed	\	\	kald	\
turned	turn	turn	\	\
covered	\	\	\	\
brand	\	\	\	\
mound	\	mountain	\	\
blond	\	brond	blownd	\
hound	\	\	\	\
blind	bleed	\	blind	bilid
beard	\	bored	bird	bard
arrest	\	aret	\	\
feast	\	fest	fast	first
boast	boasted	\	boost	\
collect	collected	\	\	cold
elect	electric	\	\	\
connect	continent	chronicle	\	\
drift	\	\	\	\
child	\	\	\	\
friend	\	\	\	frowned
third	\	thunder	\	\

Appendix O

Regular words, irregular words, and non-words used in case studies

Regular words	**Irregular words**	**Non-words**
help	give	geronth
nothing	surface	retash
window	island	losh
wish	iron	avisher
seven	ocean	nart
party	sugar	drock
report	rhythm	shathom
telling	foreign	golthom
calling	silence	cheed
trunk	ghost	bantost
frog	wolf	krog
shock	sword	meesh
bake	echo	thiffer
rainbow	whisper	plish
athletic	furious	gommy
thorn	cough	fleg
smog	yacht	lishoo
shudder	bouquet	lumnooth
radish	regime	torlep
marathon	meringue	imchim

Appendix P

Spellings on irregular words, regular words, and non-words in case studies

Target		AB	MD	JG	MB
iron	i	iran	ion	ioen	lone
ghost	i	gost	goth	gost	goset
foreign	i	roran	forn	forun	foren
sugr	i	suger	suge	soger	suger
meringue	i	mrang	marng	mrang	murang
give	i	\	\	\	\
island	i	iland	iland	iland	ialand
surface	i	srfis	surfis	serfis	serface
yacht	i	yot	yot	yot	yole
regime	i	rersen	rozem	rasheme	rusen
bouquet	i	boucay	bakay	boke	bakay
whisper	i	wicper	wisp	sisper	wisper
ocean	i	oran	oshne	oshun	osen
sword	i	surd	sonrd	sord	sard
wolf	i	wolfe	\	wolef	\
cough	i	coff	café	cof	cofe
rhythm	i	riym	hirm	rithum	rithen
echo	i	ecow	ecow	ecow	ecow
silence	I	silansh	sillns	silents	silans
furious	i	furas	pyunis	fuoreus	fures
shock	r	soch	socke	sok	\
calling	r	\	\	caling	carling
trunk	r	trunt	\	\	trurck
marathon	r	marton	marfon	morithon	maroton
help	r	\	\	\	\
party	r	\	\	\	\
smog	r	\	smag	\	\
rainbow	r	ranbow	ranbon	\	ranebow
window	r	\	\	\	\
shudder	r	shuder	suder	shuder	soder
radish	r	\	\	\	radis
wish	r	\	\	\	\
telling	r	\	\	teling	relong
bake	r	\	\	\	bace
report	r	frpurt	nept	riport	raport
athletic	r	afleic	afletik	athletik	afletic
thorn	r	thirn	thorn	\	thom
seven	r	\	\	\	\
nothing	r	\	nofing	nuthing	nofinck

frog	r	\	\	\	fog
geronth	n	gronth	gerof	gerth	geolf
retash	n	retash	retash	retash	retas
losh	n	losh	losh	losh	losh
avisher	n	avesa	avsh	avish	avise
nart	n	nart	nort	nart	nart
drock	n	erok	drock	drok	drock
shathom	n	shaton	shafom	shathon	safon
golthom	n	golton	golfom	gothon	gothum
cheed	n	ched	ched	cheed	cheed
bantost	n	bantast	bantost	bantost	bantost
krog	n	crog	crog	crog	crog
meesh	n	mech	mesh	neesh	meese
thiffer	n	fifer	fifer	thithu	filha
plish	n	plish	llish	plish	plish
gommy	n	gome	gomeg	gomy	gomy
fleg	n	flag	fleg	fleg	fleg
lishoo	n	lishow	lishooh	lishoe	lishow
lumnooth	n	lumnuth	lomnoof	lumnooth	lunof
torlep	n	turtap	torlep	torlep	turlep
imchim	n	imchim	imcim	imchim	imshim

Appendix Q

Reading errors on irregular words in case studies

Target	**AB**	**MD**	**MB**	**JG**
wolf	+	+	+	+
yacht	vack	yok	yatched	yatched
rhythm	riv	rhyme	rye-thum	rithium
sword	+	shord	sword (w)	swore
sugar	+	+	sugger	cigar
island	+	+	izland	izland
suface	+	shuface	+	+
regime	redeem	fagma	regaim	reg-ime
furious	+	famous	ferocious	furry-ous
ghost	+	+	+	+
give	+	+	+	+
meringue	merju	mangu	meringew	+
cough	+	caught	caught	kowguhuh
ocean	+	+	+	okean
silence	+	silver	+	slext
whisper	+	+	+	+
foreign	+	forgiven	forgain	forigen
iron	+	aron	+	iron
bouquet	borkew	brought	borkwit	banqwets
echo	+	+	etcho	etchuo

Appendix R

Word analogy task

Instructions: I am going to say two words. Listen to the change I make on the second word. I will then say another word and I want you to change it in the same way I did with the first two words. Let's have a practice.

<u>Practice items</u>

long	length
wide	______
bring	brought
swim	______

<u>Experimental items</u>

1.	anger	angry
	strength	______
2.	sing	song
	live	______
3.	teacher	taught
	writer	______
4.	walk	walked
	shake	______
5.	see	saw
	dance	______
6.	happy	happiness
	high	______
7.	work	worker
	write	______
8	cried	cry
	drew	______