Acquisition is not spongelike: Using repetitions required to learn words to investigate influences on word recognition in Year 1 English children

Mark Dennis Masidlover

Thesis submitted for the degree of Doctor of Education (Educational Psychology)

School of Education, University of Sheffield

October 2014

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University of Sheffield Ed.D. (Educational Psychology) thesis, October 2014

Abstract

How many times do children learning to read need to see printed words for the words to be reliably recognised? Reitsma (1983) demonstrated that Dutch children who had made average reading progress for six months could read words they had seen as few as four times significantly faster than similar unfamiliar words. This research has been quoted widely as suggesting that children learning to read English need similar level of exposures to learn unfamiliar vocabulary.

To investigate this claim, a small group of English Year 1 children were assessed on words they had encountered varying numbers of times in books used to teach them to read. In addition to investigating whether four repetitions were sufficient for a variety of words, the vocabulary was analysed to evaluate the relative level of repetitions required for children to reliably recognise words varying in decodability, word class and morphemic complexity. The overall sample of words needed to appear in books more than 15 times for reliable recognition. Words children could decode required significantly fewer repetitions than those beyond their decoding ability. No significant differences were found for repetitions needed by words varying in word class or morphemic complexity. Decodable words, out of all the categories analysed, were those requiring the fewest repetitions, reliable recognition being attained within the band from 4 to 15 occurrences, and might therefore be considered as candidates for ‘spongelike acquisition’. Non-decodable words, however, did not attain reliable recognition until repetitions exceeded 40, confirming in an indirect manner the critical importance of decoding skills for children’s reading development. Repetition of vocabulary, though, a neglected factor in research, appears to be equally essential, and the results of this small pilot study seem to warrant a larger-scale investigation. Above all, what this study has shown is that, for at least some children and some types of word, acquisition is not ‘spongelike’.

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Chapter 1 Introduction

1.1. The central topic of this dissertation

How easy is it for children to learn to recognise printed words? Can they do this after seeing them only a few times? Does the level of repetition needed vary for different types of word? The amount of repetition of words required for reliable recognition is the theme of this dissertation, with research question 1 '**Are four repetitions of a group of words sufficient for them to be read subsequently to a 78% level of accuracy?'** setting the scene by questioning a widely quoted level of repetition presumed to be sufficient for learning new words.

The theme of repetitions is continued in the remaining research questions, where it is used to investigate a range of influences on beginning readers.

1.2. Repetition in books for beginning readers

Research on rapid orthographic learning carried out in the laboratory, which showed that Dutch children with six months' reading experience read words seen as few as four times significantly faster than similar unfamiliar words (Reitsma 1983), has been accepted as implying that new words can be learnt by beginning readers with very few encounters indeed, and that this extends to children learning to read English (Adams 1990, Ehri 1999, Juel and Minden-Cupp 2000). Research on whether this accepted truth applies to beginning readers is very scarce, as is any obvious attention to the possible importance of level of repetition in early reading materials, leading two American researchers to write: "At the present time, repetition of specific words does not appear to be a factor in the design or selection of individual texts or sets of texts in instructional programs for beginning readers” (Hiebert and Martin 2009 p.47). Hiebert and her colleagues had previously complained not only about the lack of attention to repetition in the design of published texts for beginning readers, but about the ‘meagre contemporary research’ on the level of repetition required for children to learn to recognise new words (Menon and Hiebert 2005). Their concern was partly motivated by the high incidence of published texts where new words appear very few times, reducing the opportunities for children to learn the vocabulary. Although they were discussing educational practice in the United States, materials for young readers in the UK suffer from similar deficits, with researchers who created a database of published English reading schemes for 5- to 9-year-olds describing the level of exposure of the vocabulary as “dramatically skewed towards the lower frequencies” (Masterson et al 2010 p.227).

1.3. Limited repetition and lack of progress in learning to read

Both sets of researchers consider that the tacit assumption that the learning of new words by children occurs with very few encounters is not warranted, with Stuart et al (2000) demonstrating that high repetitions were essential for English beginning readers. The possible negative consequences have rarely been studied, with the only paper located which raised the topic relative to beginning readers inserting it very much as an aside, in research on the effects of reading scheme structure. In a classic study of early reading schemes in the United States, Juel and Roper/Schneider (1985) briefly mentioned the possible impact of selecting an inappropriate level of repetition. They had compared the progress in reading of two groups of children receiving identical phonics instruction, but who were taught using different basal readers. In the pre-primer phase, when children were first introduced to books, there were differences between the two schemes. The Economy series was the easier, with more regular words and a higher degree of repetition than the other series, Houghton-Mifflin. Juel and Roper/Schneider reported that, of the 50 children who started on Houghton-Mifflin, 10 had to be moved to an alternative series because teachers found they were unable to learn the core vocabulary.

The mean number of repetitions of words in the Economy series was 26.3 (s.d. = 37.5) and in Houghton-Mifflin, 15.1 (s.d. = 16.9). With variations in both the number of regular words and frequency of exposure it is not feasible to attribute a causal connection between failure to progress on Houghton-Mifflin and the lower level of repetition of words, but anecdotal evidence from the children's teachers suggested they felt it was a contributory factor. No children needed to be moved from the Economy series.

For all children in Juel and Roper/Schneider’s study, a regression analysis demonstrated that repetition of words was a key factor in their ability to recognise them. And it is not simply repetition up to the point where children seem to recognise words that is important. In a study by Lemoine et al (1993), which will be discussed in detail in the critical literature review, those children who were provided with additional repetitions – ‘overlearning trials’ as they were termed – recognised more of the words in the post-tests.

All in all, as scant as the evidence may be, it seems to point to the critical importance of repetitions for young readers, particularly in initial reading schemes where the vocabulary is presumed to be learnt for long-term retention.

1.4. The purpose of the research and Its relevance to literacy difficulties

The initial lack of progress of children with unsuitable reading books reported by Juel and Roper/Schneider has particular relevance to England, where the primary materials on which many children learn to read are the very reading schemes which Masterson et al reported as having many words with minimal repetitions.

This is all the more worrying as the reading scheme which caused problems for children in the Juel and Roper/Schneider study had a considerably higher level of repetition than is found in modern early reading books (Hiebert and Martin 2009).

To me, as a practising educational psychologist, the lack of research underpinnings to such a key element in early education seemed an important area where some real-world research could be helpful.

The research described in this dissertation was undertaken, in part, to provide information on the level of repetition of words in books which children used for learning to read which was associated with rapid and reliable word recognition. As basic as this may seem, if it can be used to reduce avoidable obstacles to progress in young readers it is considered a worthwhile objective.

In the case of Juel and Roper/Schneider's study, the children's difficulties were noticed quickly and remedial action was taken. It would be hoped that the children had not suffered any lasting ill effects from the inappropriate initial instruction, and that their progress would have been brought into line with that of the other children. This is not always the case – a significant proportion of children in England have long-term literacy difficulties. Brooks (2007 p.15, 2013 p.13) reported that between 2000 and 2011 around 15% of children were still at level 1 or below in reading at age 7 years, a level presumed only for beginning readers, although the latest figures (DfE, 2013) show what may be promising reductions: 13% in 2012, 11% in 2013.

Part of this may be due to a change in advocated approaches to early reading instruction with a synthetic phonics approach now seen as an essential element (D*f*ES 2007). This has considerably extended the range of grapheme-phoneme correspondences (gpc's) taught in the reception year and the early part of Year 1 from the earlier National Literacy Strategy (D*f*EE 1998, D*f*ES 2004) which was in place in England up to 2007. There is extensive evidence that systematic phonics instruction helps children, particularly younger children, learn to read (Ehri 2001a and b, Torgerson et al 2006), as discussed in some detail in the critical literature review.

1.5. Decoding skills and repetitions required for learning words

There is considerable evidence that such increased knowledge of gpc's is associated with learning words with fewer repetitions. From the very beginning, children who demonstrate skill in phonemic segmentation and knowledge of letter sounds appear to be able to apply these in learning words, and learn more words with fewer repetitions than children who do not have these skills (Dixon et al 2002, Stuart et al 2000).

With older American children from grades 1 and 2, a high level of skill at reading nonwords, which is presumed to reflect knowledge of gpc's and ability at phonological decoding, is associated with learning words with fewer repetitions (Ehri and Wilce 1983). The studies quoted above will be described in some detail in the critical literature review, as will the growth of decoding skills and the development of its underpinnings; phonological awareness, including phonemic segmentation.

The contention here is that, although phonemic awareness and knowledge of letter sounds are now seen as 'critical elements' in reading acquisition (Share 1995), the need for repetition, particularly high levels of repetition for younger readers, is overlooked in instructional material. This omission becomes even more important if one bears in mind the interaction between repetition, decoding skills and the acquisition of reading vocabulary.

Early decoding skills as exemplified in use of letter sounds to fully or partly decode words, as reported above, speeds up learning. Children's knowledge of vocabulary is seen as allowing them to infer further gpc's (Juel and Roper/Schneider 1985, Stuart et al 1999a and b), which in turn facilitates learning new vocabulary. This 'snowballing' effect, with decoding facilitating learning words, which in turn facilitates extension of decoding skills, would seem to depend upon sufficient repetition throughout the learning process and, as will be seen in the critical literature review, research on younger readers has been minimal, indeed ‘meagre’ as Hiebert and colleagues put it.

1.6. Instructional deficits and literacy problems

The concern in educational psychology practice is that literacy difficulties, stemming from a poor fit between instructional content and the needs of children, can quickly become overlaid with emotional responses and inappropriate learning strategies, producing long-term literacy difficulties. Vellutino et al (2004 p.28) talk of “problems caused primarily by experiential and instructional deficits”. In their long-term study, in which children were followed from kindergarten to fourth grade, of 9% of children referred for reading difficulties, 7½% were brought within the average range within one semester of daily intervention, the majority maintaining this level of functioning through to fourth grade.

Although there is no suggestion here that all such remediable problems relate to level of repetition of vocabulary, the fact that Vellutino et al felt that many were caused by instructional deficits makes avoiding any that could be triggered or exacerbated by poorly designed texts, where children simply do not experience enough exposure to words to learn them, a worthwhile objective.

1.7. Optimising instructional design

The purpose of the research was to begin to evaluate the importance of repetition in relation to vocabulary in reading schemes used widely in the UK, which were in use in the school used for the study.

In addition, as Hiebert and Martin (2009 p.61) point out, in the minimal research exploring this topic “studies have failed to delineate how repetitions differ as a function of word features.” Although this is not entirely true, and the research on decodability previously mentioned has demonstrated clear benefits in lowering the number of repetitions needed to learn words, this has rarely been studied for other known influences on children’s recognition accuracy. For this reason research questions 3 and 4 look at whether the amount of repetition needed for reliable recognition is different for words varying in word class and morphemic complexity. In addition, there is a further look at words differing in decodability, as there has been no research on children of the age range included in the dissertation research.

Different word types were compared as to which required fewest repetitions, and approximate levels suggested for the repetitions each required to attain reliable recognition. All these analyses were based on the level of repetition of words children had encountered in their normal reading books, to try to avoid limitations which are present in many experimental designs.

1.8. Problems of generalisation from experimental studies to real-world learning

Much of the research on which the level of repetition needed to learn vocabulary is based has experimental designs where the number of new words encountered by the child is very limited, and where learning is through successive presentations in a limited time period, with assessment of learning being immediate or after only a few days’ delay.

Yet children learning at school may not see the new words they come across in books for some time, as pointed out by Juel and Minden-Cupp (2000):

> The problem is that most words are not commonly seen. Primary grade children are hit with an avalanche of printed words. Whilst some words are seen a lot, the most meaningful words (the content words) are not. After encountering, for example, *'hen'* and *'haystack'* in *Rosie's Walk*, it will be miles of print before children again encounter *'hen'*, let alone *'haystack*'. (p.462)

Hence using the level of repetition based on intensive teaching for short-term retention in experimental training may underestimate the repetitions needed for learning from sporadic exposure in books. Equally, although in the early stages beginners may not be hit by the full avalanche of words encountered during the primary phase, reading scheme books present the child with a far higher number of words than are used in the majority of research studies. This increases the difficulty of the learning task, and book presentation in itself has been shown to be far less effective than the flash card teaching used in many experimental studies (Stuart et al 2000).

In the dissertation research study, in order to provide an estimate of the number of repetitions of words needed for children to learn them from books, the children’s own exposure to words in the books the school used to teach them to read was calculated, and is the basis of the results reported. It is therefore based on children’s real-world experience.

This being a fairly typical approach to teaching children in England, the results hopefully have considerable validity for the wider population. Of necessity there is a loss of control on the teaching styles of the adults helping the children to read, who in this case were teachers, teaching assistants, and members of the children’s families.

One is also unaware of whether the conditions were ideal for the children to learn. It will be argued, however, that the design avoided gross distortions by excluding children reading extensively from books other than school reading books, and that the gain in authenticity by not using time-limited experiments makes the findings far more relevant to normal teaching settings.

This study is innovative in attempting to use children’s exact level of exposure to a wide range of words in their reading books to estimate level of repetitions needed for reliable recognition.

1.9. Overall content of the research questions

In addition to research question 1, which asks whether the widely quoted level of four repetitions was in general sufficient exposure for the group of year 1 children studied to attain reliable recognition, research questions 2 to 4 refine the analysis by considering different characteristics of words. Finally research question 5 assesses the relative importance of these factors, and word length in letters, in word recognition.

1.10. The structure of this dissertation

Chapter 2 deals with the development of phonological awareness and its relationship with children's decoding skills, which link with research question 2. There is considerable description and discussion of research studies which assess level of repetition needed to recognise words, some with particular relevance to research question 1, although all provide information related to research questions 1 to 4. There is also some brief discussion of wider factors which influence word recognition. In addition, research background is provided on effects of word class and morphological factors on reading, which explores areas pertinent to research questions 3 and 4.

Chapter 3 provides descriptions and justifications of the methods of investigation and analysis selected, including positionality, with chapter 4 detailing the research questions and related hypotheses, together with detailed descriptions of the participants in the research and the forms of assessment used. Chapter 5 presents both the analysis of the data and supportive statistical tests. Chapter 6 provides a summary of results, relating them to the original research questions and pertinent research.

The conclusions drawn are to an extent historical: the phonics syllabus which the study children experienced was changed in the year following termination of the study. It is hoped, however, that the basic principles formulated in relation to the exposure level likely to be needed in relation to decodability of words will still apply, albeit to an altered pattern of phonic development.

Chapter 2 Critical Literature Review

2.1. Introduction

The opening sections of the review provide details of background research which relates to levels of repetition needed for learning words and the development of phonological decoding. These topics underpin research relating to research questions 1 and 2.

A brief background to research questions 3 and 4 is then sketched out, looking at the influences of word class and morphological complexity on word recognition and their impact on beginning readers.

The majority of studies of the repetitions children need to learn words reported in the critical literature review used participants with established skills in decoding, and even in the one or two studies which used pre-readers the stimuli used varied in decodability. It seemed logical, therefore, to trace the acquisition of early reading skills and its relationship with English orthography before mentioning these in discussions of studies assessing minimal repetitions for learning words.

The opening sections of the review discuss the development of phonological awareness, with particular attention to the presumed centrality of phonemic awareness in the acquisition process. As there has been considerable debate in the UK as to whether the use of small units (phonemes and graphemes) or larger units (rhymes and their orthographic counterparts, rimes) is a natural preference for beginning readers in initial word recognition, there is a fairly detailed discussion of research relating to this.

The growth of decoding skills as a heading appears well into the review, but the initial application of letter sounds in reading is considered to be the first step in this process. They are in effect single letter gpc's which, it will be argued, are an initial simplified system which the child builds on. Hence the first steps in decoding form part of the discussion of the place of phonemic awareness and letter sounds in the reading process. The section identified as decoding skills moves from the widening knowledge of a range of gpc's to the use of sublexical patterns which contain more than one gpc in reading.

Finally, the possible contributions of wider language skills and skills in other areas to the reading process are discussed, before the focus shifts to the direct experiments on the minimal repetitions needed to learn words. As the dissertation research assessed the children's recognition of words encountered intermittently over their first year of instruction, it was of interest to look at research studies where words were tested after lengthy periods of retention.

The final sections of the review initially describe the evidence of children's differential learning of function and content words, considered in research question 3, followed by discussion of research relating to the awareness and use of the morphological structure of words, which underpins the comparison between recognition of mono- and multi-morphemic words carried out for research question 4. These sections include a summary of how such factors might influence the level of repetition needed for learning words.

2.2. The development of phonemic awareness

Much credit has been accorded to Isabel Liberman and her colleagues at Haskins Laboratories for formulating the leitmotif which shifted the direction of research from a focus on visual aspects (Gibson and Levin 1975) to a more linguistic approach. "To learn to read, children must map the written word to the spoken word. It seemed plain to us that to do this, they must have some recognition of the phonetic structure of spoken language" (Liberman 1971, quoted in Liberman et al 1979). There is an illusory self-evident simplicity in the proposal. If we need to write a word whose spelling is not yet familiar to us, we can split it into phonemes, write a suitable grapheme for each phoneme, and provide a written form from which an experienced reader could approximate the target word's pronunciation. Similarly, by applying the reverse process we could pronounce a new word. It might not be absolutely accurate, as the conversion process in English is less straightforward than in many other languages.

The analysis of speech into phonemes to be represented by letters, though, seems to us, as fluent readers, a relatively easy process. Our judgement, however, is flawed – learning to read has permanently altered our perception of words. Acquiring the ability to read an alphabetic language has been likened to catching a virus which has immediate and profound effects. "This virus affects all speech processing, as now whole word sounds are automatically broken up into sound constituents. Language is never the same again" (Frith 1998 p.1011).

The acquired ease with which we fluent readers hear phonemes in words in no way represents the ease of isolating them from signals in speech. "Phoneme boundaries are not marked acoustically ... because a consonant segment ... will ... be merged with the vowel" (Liberman et al 1977). There is therefore no acoustic criterion by which the three phonemes in /bæg/ can be segmented, despite the simplicity of this task for most readers.

The task can be far from simple for children learning to read, and the key role of phonemic awareness in the acquisition process was clarified by the exploration of its development in children, and its relationship with progress in reading. The critical importance of the ability to perceive and manipulate the phonemes in words, and to associate them with letters of the alphabet, emerged from a multiplicity of studies, and these skills are now seen as 'critical co-requisites' (Share 1995).

The significance of this to reading researchers was exemplified in a comment by Adams who, having just published a tome summarising the research (Adams 1990), stated in an article discussing it: "To my mind, the discovery and documentation of the importance of phonemic awareness.... is the single most powerful advance in the science and pedagogy of reading this century" (Adams 1991 p.392).

The sections which follow describe the research on children's development of skills in perceiving and manipulating units of sound in words, which culminates in the development of phonemic awareness.

After an initial introduction to the different units of sound which have been investigated and their sequence of development, their relationship with acquisition of reading skills is considered from both correlational and training studies. This leads fairly naturally into the place of phonemic awareness in the development of decoding skills, and the extent to which the latter affect word recognition skills in the developing reader, and their relationship with reading and comprehension of text, and to the reasons underlying a hypothesised reduction in repetitions needed for learning decodable words.

2.2.1 Phonological awareness: the skills and their sequence of development

From the outset, investigation into children's development of phonemic awareness included their ability to perceive and manipulate larger units of a word than phonemes. Liberman et al (1974) investigated skill in counting both syllables and phonemes. Other investigators have looked at onsets, rimes and (word) bodies (Duncan et al 2006, Goswami 1986, Stahl and Murray 1994). Sensitivity to the sound structure of words, from small to large units, is generally referred to as phonological awareness. A multiplicity of studies of the sequence of development across a variety of languages "have yielded a remarkably similar picture, despite differences in the phonological structure of the languages being learned" (Ziegler and Goswami 2005), namely from syllable awareness around 3 to 4 years, to onset-rime in the preschool years, and to phoneme awareness once reading is introduced (Ehri 2005, Liberman et al 1974, Treiman 1985). Although some researchers now believe that variations exist in this sequence cross-linguistically, the original ‘universal’ sequence gave rise to an influential theory of reading acquisition, and this will be presented before going on to discuss the recent cross-linguistic research.

The universal sequence was seen as a progression from shallow sensitivity to large units (syllables, rhymes) to deep sensitivity to small units (phonemes) (Lundberg 1978 quoted in Lundberg 2009, Stanovich 1992). Shallow sensitivity is shown in tasks where children can match similar words on the basis of sensitivity to global sound similarity, for instance knowing that *rug* and *hug* rhyme, but where they will be quite unable to specify which parts of the words rhyme. This requires explicit analytic ability, which is considered deep sensitivity, exemplified at phoneme level, for instance, by deletion tasks where the child is asked to say what sound is left when /b/ is taken away from /bæg/.

2.2.2 Sequence of development of units of phonological awareness as a guide to their use in learning to read

Goswami and Bryant (1990) proposed a theory in which children’s skills at phonological awareness tasks whilst pre-readers underpin in a very direct way their strategy in learning to read: “When children first learn to recognise written words... they associate the spelling sequences representing these words with two phonological units, the onset and the rime” (Goswami 1993 p.471).

Based on the sequence of emergence in English, as sensitivity to onset-rime was evident before children were instructed in reading (Treiman 1985, 1992), it was hypothesised that beginning readers learn to read by paying attention to letters that correspond to onset and rime in print. Equally, as phonemic awareness is generally poorly developed at that stage (Liberman et al 1974, Fox and Routh 1975, Stuart and Coltheart 1988), awareness of the individual phonemes making up the rhyme was presumed to be a later development. The theory developed from some earlier research in which Bradley and Bryant (1983) demonstrated that children's sensitivity to rhyme predicted progress in reading. This provided a theoretical link, suggesting the importance of rhyme awareness as a mechanism in reading acquisition, but in the new theory with a clear causal link, it led to a further claim: "[T]hat the relationship between children's awareness of rhyme and reading will hold even after control[ling] for differences in children's ability to detect phonemes" (Goswami and Bryant 1990 p.111).

Thus at a fairly early stage in research on the importance of phonological awareness, there was a theory which questioned the preferential status of the phoneme which by the early 1990s had already been shown through correlation and intervention studies to have a strong relationship with reading progress (Liberman et al 1974, 1979, Treiman and Baron 1983, Wagner and Torgesen 1987).

Rhyme awareness was not only seen as a critical causal mechanism in learning to read, but it also acted indirectly by helping children become sensitive to phonemes. As Bryant stated (2002 p.41), there is "an indirect route whereby onset-rime awareness feeds the development of phoneme awareness which in turn affects the child's reading..."

This suggested shift from the importance of phonemes in reading acquisition to rhyme awareness and rime units had implications for teaching children to read. It seemed to suggest that it would be appropriate to include training on rhyme awareness and onset-rhyme analysis of spoken words, and similar analysis of printed words when reading was being introduced, on the assumption that tailoring instruction to children's existing pattern of development would be more effective for teaching children to read than starting with phonemic awareness, generally minimally developed in children starting school.

2.2.3 The large-unit-first debate in reading research

The syllabi for beginning and pre-readers, both in the US and in the UK, began to include activities to develop rhyme and analogy skills, which many researchers felt was not warranted by the evidence (Macmillan 2002, Savage 2001).

Criticisms were levelled at the research evidence on beginning readers' use of analogy (Savage 1997, Savage and Stuart 1998). Doubts were raised as to whether rime units were preferentially used in word recognition (Duncan et al 1997, 2000, Seymour et al 1999), and there was experimental evaluation of the relative effectiveness of teaching approaches which focused on instruction based on phonemes or onset-rime for beginning readers (Bruck and Treiman 1992, Macmillan 2002, Walton 2001a and b). Some studies questioned the early findings that onset-rime sensitivity predicted reading progress, and certainly whether it did so once controls for phonemic awareness were in place (Duncan et al 1997, Hulme et al 2002, Muter et al 1998, 2004, Stuart 1995).

2.2.3.1 Use of analogy by beginning readers

Savage (1997, 2001) pointed out that, even though children seem to make use of analogy in the presence of a clue word which contains the rime of unfamiliar words they are trying to read, in Goswami's original experiments (Goswami 1986, 1988) there was very little evidence of use of analogies once these concurrent prompts were removed (Savage 1997), and certainly any effects obtained were substantially reduced (Muter et al 1994). Goswami (1999 p.222) claimed that her early experiments simply demonstrated that children could make use of "an analogy mechanism" rather than being a guide to classroom reading.

Many researchers, though, felt that it was precisely the relevance of reading by analogy to 'classroom reading' that should form the evidence base for its inclusion in an initial reading curriculum. With this in mind Duncan et al (1997) evaluated children's early spontaneous use of analogies by assessing whether nonwords constructed with rimes encountered at high frequencies in their reading books were read more accurately than those with rimes encountered at low frequencies, but they found no significant effects.

However, in their second year the children "pronounced nonwords with high frequency rimes more accurately than nonwords with low frequency rimes' (Duncan et al 2000 p.1086). This improvement in children's sensitivity to rime frequency with increasing experience of text and reading skill continues to develop, Bowey and Underwood (1996) showing that the use of analogies in reading rimes in nonwords increased with the word reading skills of children from second to fourth grade.

Hence the argument is, not that children do not make use of analogies, but that spontaneous use in beginning readers is limited and grows with increasing reading vocabulary. Certainly the suggestion that they are preferentially used over and above small unit gpc's by novice readers, as theorised by Goswami and Bryant, seems questionable.

In fact, some fairly strong evidence that rime units are not favoured in this way came from a study carried out by proponents of an early curriculum which included extensive onset-rime training. Walton et al (2001a and b) found that beginning readers after several months' rime instruction were still using small unit recoding for unfamiliar words containing rimes they had been taught, when no cue word was provided. Goswami (1999, 2002) had often suggested that lack of spontaneous use of analogy in children who had been taught to read using a small unit phonic teaching approach was because such teaching was predisposing them to small unit processing, and they needed a supportive instructional regime. Given that the Walton et al study provided exactly this, it rather undermined her position.

2.2.3.2 Comparisons of intervention using rime-based training with small unit teaching

There is only correlational evidence which seems to support the possible indirect effects of increasing onset-rime sensitivity on phoneme awareness.

Anthony and Lonigan (2004) reanalysed Wagner et al's (1997) data from their five-year longitudinal study, and found that "at each grade level onset-rime sensitivity was a strong predictor of subsequent phonemic awareness" (p.49). Clear direct evidence from intervention studies on this point has not been found. Thus, although Lundberg et al (1988) obtained improvement in phonemic awareness after training rhyme awareness, they had also included phonemic awareness training, which could have been responsible for the effect. Similar equivocal results were obtained by Qi and O'Connor (2000), who found similar improvements in phonemic awareness in two groups, one trained on phonemes, the other trained on both onset-rime and phonemes.

In terms of direct impact on reading progress from a rime-based teaching strategy, early research by Bruck and Treiman (1992) showed benefits with faster learning of words taught using clue words with an identical rime to the unfamiliar words, contrasted with groups who used analogies to the head (clue word *pig*, unfamiliar word *pin*) and to the vowel (clue word *pig*, unfamiliar word *bit*).

However, a day after such training with no clue word present, the rime-based group retained the lowest number of taught words, even when number of trials provided for learning was controlled as a covariate. Bruck and Treiman suggested that the vowel-trained group, who performed best on a generalisation test, learned most about segmentation, and "the better performance... reflects the utility of grapheme and phoneme units in beginning reading" (p.386). This undermined the idea that rime-based teaching was the most effective strategy to adopt for beginning readers.

2.2.3.3 Macmillan's meta-analysis: the training studies

Macmillan (2002) carried out an extensive meta-analysis of studies looking at the correlation of rhyme awareness and later reading progress, as well as training studies. There were 13 of the latter, only one of which trained rhyme awareness in speech without including additional skills (Duncan and Seymour 2000, cited in Macmillan 2002). This showed no difference in reading progress between the trained group and the control group on the BAS word reading test, although the trained group had superior rhyming skills.

The remaining 12 studies mixed phoneme awareness and rhyme awareness training, or trained rhyme awareness as well as onset-rime in reading. These studies "were only found to produce positive effects among older, already reading children. Amongst beginning non-readers.... other forms of instruction produced significantly superior reading progress" (p.25). These "other forms of instruction" focused on phonemic awareness (e.g. Deavers et al 2000, Solity et al 1999). Certainly Macmillan's meta-analysis raised doubts about the extensive use of rhyme awareness and onset-rime in reading at the introductory stage, although it did suggest a place for them with older readers.

Levy (1999) had a similar view, based on the results of a large-scale study of 125 grade 2 problem readers. She felt that onset-rime training was definitely worth including in intervention "as the initial method of instruction for setting up new reading vocabulary” (p.92), as children had learnt most rapidly with this approach.

Even Savage, who had very strongly questioned the use of such approaches with beginning readers (Savage 2001), reported some positive results obtained with Year 1 ‘at risk’ readers (Savage et al 2003), where children included in the rime intervention group performed significantly better on blending tests than phoneme-trained children. Savage et al ascertained that poor readers found rime-based approaches easy to learn. This echoed earlier comments by Bruck and Treiman (1992) that “even children with a low level of reading skill can grasp the use of rime based analogies” (p.385).

However, even for these readers, researchers felt a need to retain a focus on phonemes, Levy (1999) adding a rider to her recommendation on the use of rimes in introducing reading vocabulary, by seeing it firmly as an introductory phase “with these larger units (the rimes) gradually broken into phonemic segments for the child” (p.385).

2.2.3.4 Rhyme and onset-rime awareness as a predictor of later reading progress

The strong claim that awareness of rhyme would predict reading ability after controlling for children’s level of phonemic awareness made by Goswami and Bryant (1990) was refuted in two studies by Muter and colleagues (Muter et al 1998, 2004) and one by Hulme et al (2002). “Rhyme skills were not a significant unique predictor of reading skills... after phoneme sensitivity was controlled” (Muter et al 2004 p.677). “Onset-rime skills ma[de] no additional predictive contribution (to reading skills) once phonemic skills were accounted for" (Hulme et al 2002 p.2).

Macmillan (2002), with a broader view on correlation, included some studies which did not control for phonemic awareness, but after reviewing some 32 studies concluded that the evidence "does not support the idea that rime awareness was importantly related to reading ability" (p.23).

Two recent meta-analyses covering a large number of studies have, however found such a correlation, although it is substantially less than that found for phonemic awareness. The National Institute for Literacy (2008) considered 299 articles, although they may not have been subjected to the same extreme rigour which Macmillan used, and there is no clear report of methodological issues relating to the control of extraneous variables, etc. However, it reported a moderate relationship between rhyming ability measured in kindergarten or earlier and later reading ability, with an average correlation of 0.29. All articles used were from refereed journals and subject to scrutiny and rejection by experienced researchers in a three-stage filter process. The result is also surprisingly similar to a very recent meta-analysis by Melby-Lervåg et al (2012), who looked at 235 studies from 1975 to 2011 and obtained an average correlation of 0.28 between rhyme awareness in pre-school and kindergarten, and decoding skills.

The argument in the literature now seems to have shifted to not denying a relationship between rhyme/rime and reading, but emphasising that it is a far weaker relationship than that found for phonemic awareness. The average correlations for the latter reported by the National Institute for Literacy and Melby-Lervåg et al were respectively 0.42 and 0.43.

The comparative strength of the links of these phonological awareness skills with reading is further reinforced by the relationship with reading problems. In a comparison of rhyme awareness and phonemic awareness skills of dyslexic children compared to reading-age controls, a further meta-analysis of effect sizes in studies carried out by Melby-Lervåg et al produced respective deficits of d = -0.37 and -0.57, showing significantly more powerful association with phoneme-based skills.

There now seems to be reasonable evidence that onset-rime sensitivity is part of a group of inter-related phonological awareness skills and it does predict later reading, albeit not as strongly as phonemic awareness.

2.2.3.5 The Goswami and Bryant theory of onset-rime's position in reading acquisition: questioning the theoretical basis for their hypotheses

The original theory had based the presumed importance of onset-rime on children's shallow sensitivity to rhyme awareness tasks as pre-readers. Duncan and colleagues have questioned this basic premise (Duncan et al 1997, 2000, Seymour et al 1999). They feel that shallow sensitivity to rhymes is insufficient as a basis for analysing speech sounds for the purpose of reading, for which deep sensitivity is needed, as seen in the analytic ability associated with phonemic awareness. They have demonstrated clear differences in preschoolers' ability to do tasks requiring shallow and deep sensitivity to rhymes, using a new measure – the ‘common unit task’ – which looks at ‘deep’ sensitivity. They used this alongside the widely used oddity task, a test of shallow sensitivity, developed by Maclean et al (1987). The oddity task requires the child to name the odd one out from a series of three words spoken by the experimenter, where one differs on the rhyme unit (e.g. *hug, jug, net*). The common unit task requires identification of the common sound in pairs of words. The child is introduced to a puppet “who likes to say bits of words which sound the same” (Duncan 1997 p.193). There is some practice, with feedback, and then the child is required to help the puppet say the common sound from the rhyming words presented by the experimenter with no corrective feedback (e.g. *hug-jug*).

Duncan et al (1997, 2000) carried out a two-year longitudinal study, starting when children were in the nursery, and found that the two tasks produced very different results. The same group of children whose mean percentage success was just above 90% on rhyme awareness on the oddity task at the end of their preschool year obtained a success rate of around 20% on the common unit task, which used vocabulary from their reading books, 10 months into the following school year. At that point, although the children only attained a 20% success rate on rhymes in the common unit task, their success rates when identifying single phoneme onsets and codas were around 100% and 90% respectively, also on the common unit task.

The results for these children are thus in accordance with the universal sequence, although they add a further level of complexity. The early emerging shallow sensitivity to large units corresponds to implicit awareness of rhyme units, as shown at preschool level with the oddity task. The later stage, of deep sensitivity to small units, is seen in the almost total success at individual phoneme level on the common unit task towards the end of the first year of schooling.

The additional level of complexity beyond the normal universal sequence is the late development of deep awareness of large units. For instance, explicit awareness of rimes, using the common unit task, was very poor at age 6 (around 20%), even after a year of reading instruction. Seymour et al (1999) suggested it develops more gradually, improvements becoming more obvious after reading age has advanced beyond seven years; at that stage the same group had scored at around an 80% success rate.

2.2.3.6 Variations in the universal sequence

The use of the common unit task has demonstrated variations in the supposed universal sequence of phonological awareness. In a series of cross-linguistic studies (Duncan 2006), deep awareness of syllables, a large unit, was found to precede deep awareness of phonemes, a small unit, the opposite to the expected order, in French children.

French children had a mean percentage accuracy on syllables of 90% at the age of four years, whilst being at floor levels on phonemes at the same task. Sensitivity to phonemes did not increase in accuracy until they started reading, some two years later. English children were at floor level on syllables on the common unit task at age four, showing cross-linguistic variation which is felt to relate to differing speech rhythms and syllable structures in the two languages (Duncan 2010).

An interesting point to note is that, despite the explicit awareness of syllables in French children, postulated as the level necessary for recognising similar size units in initial reading by Duncan and her colleagues, in a study by Cole (1999 p.525) French children used small units (i.e. grapheme-phoneme correspondences) when they began to read “by February of the first year of instruction in schools that included a wide range of teaching methods (both whole word and alphabetic)”. It was only after several months more that syllable-size units were used in word recognition, and then only by good readers (Cole 1999).

With what appear to be higher levels of skill at large unit phonological awareness tasks than English children, there should be an even stronger preference by French children for use of large units in early word recognition, if Goswami and Bryant’s theory is correct. Apparently this is not the case, so it may well be that the use of large units made up of multiple letters, in a system which, as Macmillan (2002) points out, is by its very nature a phonemic system, with individual letters initially standing for single sounds, requires extensive practice with small units until perceptual and lexical access is fluent (Wolf and Bowers 1999), before children’s sensitivity to large units can begin to be reflected in word recognition. Phonemic awareness thus still seems critical, even where language characteristics vary the sequence of phonological development.

2.3. Phonemic awareness and reading ability

2.3.1 Introduction

After considerable debate over the relative importance of onset-rime and phonemes in early reading, there appears to be a general consensus that larger units such as the rime are not used preferentially in initial word recognition, and that small units, phonemes, are. The accumulated evidence on the critical nature of phonemic awareness and letter sounds for reading acquisition from both correlational and intervention studies is described in the sections which follow.

2.3.2 Correlational studies of phonemic awareness and reading ability

It has been known for some time that there is a strong link between children's ability at phonemic awareness tasks, particularly segmentation, and their concurrent and future reading ability (Lundberg et al 1980, Stanovich et al 1984). Share et al (1984) demonstrated, in a longitudinal study of 543 Australian children, that phonemic segmentation ability at school entry was the joint best predictor (with letter names) of reading ability, correlating 0.66 at the end of kindergarten and 0.62 at the end of Grade 1, out of 39 predictor variables.

Since that time, studies have accumulated in increasing numbers confirming the relationship, including those carried out more recently (Georgiou et al 2008, Lervåg et al 2009, Muter et al 2004). Fortunately, several meta-analyses have summarised the results of the better-designed studies, thus consolidating the evidence. Two recent meta-analyses, Melby-Lervåg et al (2012) and National

Institute for Literacy (2008), reported that the average correlations between phonemic awareness and reading ability were respectively 0.43 and 0.42, a 'strong relationship', and, as commented in the previous section, supportive evidence for this link emerged from the sizeable average deficit in phonemic awareness effect sizes in dyslexic children compared to reading age controls (d = -0.57 in the Melby-Lervåg et al meta-analysis).

2.3.3 Experimental and training studies of phonemic awareness and its relationship with reading ability

The training research linking phonemic awareness with reading ability has a similar long history to the correlational studies, with articles published in the 1970's and 1980's (Bradley and Bryant 1983, Fox and Routh 1976, 1984, Treiman and Baron 1983), and an exponential rise in further studies up to the current period. There have been two meta-analyses of a large number of studies, although not quite as recent as that of Melby-Lervåg et al, those of Bus and van IJzendoorn (1999) and Ehri et al (2001a).

Bus and van IJzendoorn included 34 studies which evaluated improvements in phonemic awareness and reading ability. All had control groups, but were not necessarily fully randomised designs. The meta-analysis showed statistically significant improvements in children's phonemic skills and reading and spelling, providing supportive evidence of a causal relationship between phonemic awareness and the acquisition of literacy skills. Younger children, particularly pre-schoolers, showed stronger effects, but they would have had far fewer skills at the outset and hence more room for improvement.

Ehri et al (2001a) replicated and extended the approach, including 52 studies and making 96 comparisons overall, allowing an expansion in the number of moderator variables evaluated. Criteria for the studies included were essentially the same. Findings confirmed the earlier meta-analysis but, whereas Bus and van IJzendoorn had failed to obtain significant effects on long-term improvements in reading ability, the later meta-analysis did. In addition, Ehri et al demonstrated improvement not only in word recognition but also in reading comprehension and spelling, and this was also maintained at significant levels on longer-term follow up.

In both meta-analyses, phonemic awareness training combined with the use of written letters produced better results than phonemic awareness training alone.

Letter knowledge, as an excellent predictor of later reading ability, has a long history (Chall 1967, Dykstra 1968), and the Share et al (1984) study placed it top out of 39 predictor variables. The National Institute for Literacy (2008) meta-analysis obtained an average correlation between letter knowledge and decoding of 0.50, higher in fact than the correlation with phonemic awareness, where $r = 0.42$.

It is now felt that both letter knowledge and phonemic awareness need to be acquired by children for them to understand the alphabetic principle and apply it successfully to decoding.

In a series of elegant experiments with pre-schoolers with a focus on letter-sounds, Byrne and Fielding-Barnsley (1989, 1990) demonstrated that several components have to be in place for children to learn the core 'alphabetic principle' for a sample of letter-sounds and generalise it to letter-sounds which were not taught.

In relation to phonemic awareness, not only do they have to be able to segment a given sound in a spoken word, but also realise that the same sound can occur in other words. In addition to this, they need to associate the sound with a letter and recognise it in the written word. Both are essential: neither letter-sound knowledge nor phonemic awareness alone is sufficient.

2.3.4 The reciprocal relationship between phonemic awareness and reading experience

It can be seen that the evidence underpinning the statement in Share's (1995) paper, that letter sounds and phonemic awareness skills are critical co-requisites of reading, already well-established by studies at that time, has been extended and consolidated in systematic reviews and meta-analyses of a large body of research, as well as by investigations carried out subsequent to that date. One still finds echoes of Share's dictum in a recent research paper by Hulme et al (2012 p.572): "Our findings support the conclusion that letter-sound knowledge and phoneme awareness are two causal influences on the development of children's early literacy skills."

The causal influence of phonemic awareness on reading progress is a complex, mutually supportive relationship, with increasing exposure to orthography feeding back to phonemic awareness tasks and allowing refinement of representations of phonemic segmentation of spoken words (Dixon et al 2002, Stuart et al 1999a and b). Evidence of this had been provided by Perfetti et al (1987), where partial time-lag correlations taken at three time points during the first year of reading instruction showed reciprocal effects. Thus word reading at time one had a significant correlation with phoneme deletion skill at time two, and phoneme deletion skill at time two had a significant effect on reading ability at time three. The time points for testing were about three months apart.

Hence, from the moment children begin to acquire orthographic representations, their analysis of spoken words begins to change and is evidenced in improvement of their skills at phoneme manipulation. For example, Byrne and Fielding-Barnsley (1993) pointed out that only those children in their research who could spell and decode well could delete sounds from an initial consonant cluster, and suggested that the children's knowledge of spelling patterns had been useful in developing this segmental awareness.

The orthographic influence is not always entirely supportive of phonemic segmentation; for instance, in the well-known study of Ehri and Wilce (1980), children who were asked to provide the separate sounds in *rich* and *pitch* provided an erroneous additional one in *pitch*, misled by its spelling.

In general the two skills are inextricably linked in readers, with some evidence that beginning readers' skill at segmenting phonemes in different positions of a word links to the detail in orthographic representations which they develop. Dixon et al (2002) taught three groups of reception children 10 two-syllable regular concrete nouns. The children differed in segmentation ability, with one group capable of segmenting initial and final phonemes (PA1), one initial phonemes only (PA2), and the third not able to segment at all (PA3). Groups PA1 and PA2 had similar levels of letter-sound knowledge. After training, only group PA1 were capable of discriminating between the correct versions of words they had learnt and incorrectly spelt items where the errors occurred in the medial and final positions. The other two groups were only successful when the error was in the initial position. This led Dixon et al (2002 p.295) to comment that "salient letters for orthographic storage were predictable from the children's phonemic segmentation abilities."

In addition, the same group, PA1, learnt the ten words far more quickly than the other two groups, suggesting that better segmentation skill allowed faster development of orthographic representations, going some way to provide a causal explanation as to how training phonemic segmentation skill helps reading to improve, and how decoding skills influence repetitions required to learn words.

The detailed representations which are facilitated in this way are felt to lie at the heart of accurate rapid word recognition in mature readers (Perfetti et al 1992). In addition, deficits in this process which lead to the development of poorly-specified representations are felt to be the cause of reading problems in many dyslexic individuals (Snowling 2000).

The recognition of phonemic awareness as a separate skill underpinning and improved by reading is gradually becoming a consensus view. Even Castles and Coltheart, who had previously (Castles and Coltheart 2004) argued that phonemic awareness was caused by reading, and that children might only be able to segment phonemes for which they had learnt the letter sounds, implying that letter-sound recognition and phoneme awareness are aspects of the same reading subskill, stated in a later paper that “phonemic awareness represents a meta-linguistic cognitive skill… that can be applied across a range of speech sounds” (Castles et al 2009 p.883). This conclusion was based on the results of research in the same paper where children who had received phonemic awareness training generalised segmentation ability to letter sounds not trained.

Thus, although reading is seen as triggering the skill in many English-speaking individuals, some phonemic awareness appears to develop independently. The fact that phonemic awareness is not just a skill resulting from reading instruction has also been clearly demonstrated by cross-linguistic variation, where language characteristics seem to encourage its development before reading instruction has commenced. Turkish (Durgunoğlu and Öney 1999) and Czech nonreaders (Caravolas and Bruck 1993) have a level of phonemic segmentation skill well above that found in non-reading English-speaking children of the same age.

2.4. The growth of decoding skills

The development of phonemic awareness and knowledge of letter sounds is the initial step in learning decoding skills, or it becomes so at least, once the child uses letter sounds as a guide to the pronunciation of words. Letter sounds are effectively the earliest grapheme-phoneme correspondences, both the simplest and among the most frequently occurring in texts (Fry 2004). There is evidence that children who know letter sounds can apply them in the earliest stages of their reading career (Ehri and Wilce 1985, Rack et al 1994, Stuart and Coltheart 1988).

Hence the logographic stage, which is described by some researchers (Marsh et al 1981, Seymour and Elder 1986, Frith 1985) in which children recall words by distinctive visual characteristics (Ehri 1991), attaching no sound value to individual letters, is not an essential phase in learning to read. Indeed some researchers feel that the logographic stage is not a step towards useful reading and that, although it teaches children some aspects of text structure, it should be considered as pre-reading (Share 1995), with Ehri (1991 p.411) commenting that the logographic phase does not seem to be an essential requisite "for beginners to make progress learning to read alphabetically".

The initial phase of letter sounds as gpc's, with single consonant letters and single vowel letters associated exclusively with their short sounds, gradually shifts to more complex graphemes such as vowel digraphs (e.g. <a.e>, <i.e>, <oo>), other sounds for single vowel letters as in *I, me*, etc., and common consonant digraphs (e.g. <ch, sh, th>). Common graphemes included in these early gpc's include some with more than two letters (e.g. <igh>), and eventually readers, after several years' exposure, will learn conditional rules such as the soft <c> sound before <e> and <i>, assuming they have encountered them in text. Venezky and Johnson (1973) commented that the American third-grade children they had tested had obviously not come across sufficient examples, as less than half their sample were successful in correctly pronouncing such words.

2.4.1 The slow growth of decoding in English

The acquisition of such skills is notoriously slow in English. Aro and Wimmer (2003), in a study of English and six other languages (French, German, Dutch, Spanish, Swedish and Finnish), found that it was not until grade 4 that English-speaking children's accuracy in reading nonwords (88%) was similar to that of children reading the other languages in grade 1. There are, however, a huge number of grapheme-phoneme correspondences in English. Greg Brooks (personal communication, 2011) carried out a detailed analysis of British English spelling, relating it to the 44 phonemes of the Received Pronunciation accent, and estimated that there are 89 graphemes and 138 grapheme-phoneme correspondences for a child to learn, just for the main system of English spelling, and about a further 195 graphemes and 403 correspondences to cover the remainder of the orthography. The further 403 correspondences include many which are rare or even totally atypical. Words which contain exclusively the common-grapheme phoneme correspondences are considered regular and those which contain lesser used or atypical variants are considered irregular.

There is a large number of irregularly-spelt words in English – Plaut (2005) estimated that these comprised about 20% of words found in adult texts. These frequent encounters with rarer gpc's introduce a high level of uncertainty when decoding unfamiliar words. For example, Brooks listed nine phoneme correspondences just for <a> as a single-letter grapheme, as in *cat, about,* *father, agent, was, bald, any, village, naïve*. Hence when children encounter unfamiliar words there is often a very wide range of possible pronunciations, leading Share (1995 p.168) to comment: "… because English, unlike most other alphabetic orthographies, has multiple ways of representing almost every speech sound, virtually every spelling is unique and therefore unpredictable."

This could be considered a slight exaggeration, as there are sources of information on pronunciation of words other than small unit gpc's which make them more predictable, such as larger sublexical patterns and morphological information, both of which will be discussed further in later sections.

2.4.2 The development of the regularity effect

Competent adult readers are faster and more accurate in recognising regular words than irregular words. This 'regularity' effect is mainly discernible in low-frequency words, the effect attenuating as words of higher frequencies are used (Stanovich 1991).

There is a developmental progression to its appearance. Backman et al (1984), looking at groups of second- to fourth-grade good and poor readers, found evidence of the effect at all grade levels studied. Logically it requires the children to have sufficient decoding skills to exhibit an advantage for regular words; where children have minimal decoding skills no such difference is apparent. Stuart et al (2000) found no regularity effect in a group of five-year-old reception children, or in some poor readers in Year 2 in an earlier study (Stuart et al 1999a). The latter were younger than those in the Backman et al sample, which may account for the difference in the results.

The effect found by Backman et al applied to words at all frequency levels initially. Thus both good and poor readers in grades two and three had regularity effects on high-frequency words, whereas good readers in grade 4 read high-frequency regular and irregular words equally well, but not so the fourth-grade poor readers, where high-frequency regular words still retained an advantage. Given that the frequency effect associated with competent adult readers only disappears for high-frequency words, it follows that it is only when children reach a similar high level of exposure to words as those for adults that the regularity effect would decrease. The less skilled grade 4 readers in Backman et al's study were quite likely to have had less exposure to print than the good readers (Stanovich 1986) and, as a consequence, less exposure to vocabulary and limited opportunities to learn the less common gpc's, both of which may be necessary for more accurate reading of irregular words, and which in good readers leads to the attenuation and disappearance of the regularity effect on high-frequency words.

Some researchers attribute the lack of a regularity effect for high-frequency words to their being recognised by direct visual access, which does not require the phonological processing on which the regularity effect depends (Seidenberg 1985), a point which will be further discussed in later sections on repetition and reading development.

2.4.3 Irregular words and the novice reader

Clearly, even after children have learnt some of the common grapheme-phoneme correspondences, irregular words with by definition 'atypical' correspondences, and regular words with rare gpc's, create difficulties in word recognition. Solity and Vousden (2009) calculated the percentage of such words in both children's books and adult texts for the children who had learnt the 62 major grapheme-phoneme correspondences taught in the Early Reading Research project (Solity 2000).

For a mixture of high-quality children's books, the 'real books' used in the project for teaching children to read, only two thirds of words encountered (67%) (tokens) were decodable. Similarly proportions of two thirds decodable and one third non-decodable were found for the database of the Oxford Reading Tree books and adult texts extracted from the MRC psycholinguistic database (Coltheart 1981). It can therefore be expected that around a third of words in text will be beyond the decoding ability of even competent beginning readers with knowledge of high-frequency gpc's.

That is not to say that children will necessarily fail completely in their attempts to read them. If such words occur in continuous text, sufficient aspects of the word may be regular for the approximate pronunciation built up by the child to allow selection of suitable candidates based on context, so that "partial decoding may be adequate for learning irregular words in the course of everyday reading" (Share 1995 p.166).

Evidence to support the hypothesis that decoding, even when partial, still plays a role in recognition of irregular words comes from two sources, the rate of learning of such words, and correlations with the reading of regular words and nonwords. In relation to learning rate, Byrne et al (1992 p.149), in a study of 2nd-to 4th-grade Australian children, commented that “the pattern of the data is consistent with the observations that children with good decoding skills learn new irregular words quicker than children poor at decoding.”

Correlation data are more numerous. Stanovich and West (1989) obtained correlations of 0.69 between naming of regular and irregular words and 0.46 between naming of nonwords and irregular words, whilst Stuart and Masterson (1992) obtained an extremely high correlation of 0.93 between reading of regular and irregular words by 10-year-olds. In addition, in a recent large scale study in the UK by McGeown et al (2014) of 180 children aged 6 to 9 years, it was found that nonword reading was a large and significant predictor of irregular word reading when entered into a regression analysis after variables such as age, vocabulary, reading frequency and orthographic processing.

2.4.4 The benefits of large units for word recognition in English

The good decoders mentioned in the Byrne et al (1992) study, apart from being likely to have inferred small unit gpc’s they had not been taught, as with good decoders in other studies (Juel and Roper/Schneider 1985, Stuart et al 1999a and b), may have also learnt to make use of sublexical patterns larger than individual graphemes which have a consistent relationship with pronunciation. Kessler and Treiman (2001) and Brooks (personal communication, 2011) adopted different approaches, but both identified around 20 such units which could improve predictability.

Brooks based his approach on the phonograms listed by Fry (1999), identifying those which have pronunciations which are more predictable as whole units than from the most frequent grapheme-phoneme correspondences of the graphemes they contain, and which have a fair number of cases which heavily outweigh counterexamples. He produced a short list of around 20 which could improve predictability. Kessler and Treiman computed the consistency of pronunciation of the rimes of English monosyllables, selecting those where the letter string of the rime improved predictability in reading, and similarly arrived at just over 20 which met their criterion. There is some overlap in the letter strings identified by the two systems. Both, for instance, identify the phonogram/rime <are> as assisting the reader with pronunciation, and both encompass different lengths of unit from small to fairly long (e.g. from <ew> to <ought>).

Research evidence, though, would suggest that beginning readers make use of small units first, initially of simple one-to-one correspondences between letters and sounds (Duncan et al. 1997, Duncan et al. 2000, MacMillan 2002), so the use of phonograms/rimes could take time to develop. Evidence that this is the case can be found in a study by Treiman et al (2006), who investigated the extent to which readers were influenced by the consonantal context when reading vowel letters, with participants ranging from 1st graders to high school students. They used nonwords such as *brild\brilt, crange\crance*; some of their rimes appear as helpful in Brooks's and Kessler and Treiman's lists. Treiman et al found that the influence of the codas, measured by the accuracy of pronunciation of the vowel letters preceding them, continued to improve up to a 5th-grade reading level, with no discernible evidence of effect of consonantal context for the children scoring at kindergarten level on reading. It should be pointed out that even the mature readers, the college students, in this study only used large-unit pronunciation for nonwords 50% to 60% of the time, using small units (i.e. normal gpc's) for the remainder.

Brown and Deavers (1999) also found a far from comprehensive use of larger units when it could provide guidance to the correct pronunciation. Using similar rimes in nonwords for evaluating the type of response obtained for different age groups, they found their oldest group gave a large-unit response in 63% of words, again with small-unit gpc's used for the remainder. This leaves around 40% of some irregular words with consistently pronounceable large unit sublexical patterns still likely to be mispronounced even by older readers, for words with which they are not familiar, as one would presume that, as Share suggested (1995 p.196), apart from the irregular elements, "there will be sufficient letter sound regularity… to permit selection of the correct target among a set of candidate pronunciations" for words they know."

Despite the residual problem with unfamiliar irregular words, it is apparent that decoding through application of gpc's and larger units is a core skill in reading, and there is now substantial evidence that explicit teaching of some of these skills facilitates learning to read.

2.4.5 Systematic phonics instruction and learning to read

Ehri et al (2001b) carried out a large-scale meta-analysis of studies of the effects on reading progress of systematic phonics, where children are taught letter sounds and gpc's either by sounding out and blending (synthetic phonics) or by being encouraged to infer their existence by teacher guidance using suitable sets of words, without the teacher sounding out or blending individual graphemes (analytic phonics). This was contrasted with meaning-emphasis approaches where phonics may be actively avoided or, if mentioned, carried out on an incidental, need-to-know, basis, as in whole-language approaches (Goodman 1989, Smith 1992) and other approaches where phonics was not systematic.

Ehri et al’s meta-analysis included 38 experiments with 66 treatment/control comparisons; all were based on published programmes available for school use. The findings showed larger significant effects in improved reading skills for systematic phonics compared to other approaches, including meaning-emphasis approaches, in early grades, with smaller but still significant effects beyond first grade.

Torgerson et al (2006), in a similar evaluation, produced a meta-analysis of 12 studies which were all randomised controlled trials. Again systematic phonics was shown to produce better word recognition than other approaches.

Given that children do gradually deduce grapheme-phoneme relationships even when not taught them directly, albeit somewhat more slowly (Ehri and Robbins 1992), then phonics instruction delivered to older children is likely to have less impact, as there will be fewer skills to teach, and the larger effect for younger children found in the Ehri et al (2001b) meta-analysis might be considered predictable. In addition, 78% of the studies involving older children were of lower-achieving readers or students with reading disabilities, where it may well be difficult to obtain improvements, either because of some basic processing problems, or because non-adaptive strategies have become entrenched.

2.4.6 Phonemes, phonics and the core-phonological deficit model

The two meta-analyses by Ehri et al (2001a and b) consolidated the evidence that teaching phonemic awareness skills alongside letter sounds improved reading, with phonics tuition which systematically extended this to a range of more complex gpc's showing clear advantages over more incidental approaches of teaching phonics, or the teaching of reading with phonics actively avoided.

The introduction of children to the alphabetic principle in this way sets off, for most of them, an inference process whereby sublexical patterns which have consistent relationships with sounds are learnt independently, ranging from vowel digraphs (Stuart et al 1999a and b) to large units, be they bodies like <wa> in *water, wash*, or rimes such as <ight> in *night, fight* (Treiman et al 2006).

The initial help provided by teaching the elements of the system allows the majority of children to become competent readers.

> In sum there is a considerable volume of reading and spelling data indicating that an initially incomplete and oversimplified representation of the English spelling sound system becomes modified and refined in the light of print experience, progressively evolving into a more complete, more accurate and highly sophisticated understanding of the relationship between orthography and phonology.
>
> (Share 1995 p. 165)

With the mastery of this sophisticated system so clearly underpinned by its beginnings in phonological awareness, it has been suggested that the vast majority of reading problems are caused by deficits in that area. Stanovich (1988, 1998) described this in his ‘core-phonological deficit model’. There was almost a tacit assumption that such a deficit was the necessary and sufficient cause for literacy difficulties.

Yet Høien-Tengesdal and Tonnessen (2011 p.93), in a study of 1007 Scandinavian third- and fifth-graders, found “that approximately one half of the children with phonological difficulties still performed within the average range with regard to word decoding ability.” This suggests that additional factors other than phonology are involved in reading acquisition, and may provide compensatory routes where phonological awareness deficits occur. Although the study relates to Scandinavian languages, Snowling (2008) suggested a similar hypothesis derived from studies of English children, discussed further in the next section.

2.5. Linguistic factors other than phonological awareness affecting reading progress

Based on a series of case studies of English children at family risk of dyslexia, Snowling (2008) found that phonological deficits alone did not necessarily lead to literacy difficulties, and it was children with multiple deficits both in phonological awareness and a “quite widespread pattern of language delay incorporating slow development of receptive and expressive language skills and vocabulary knowledge” (p.147) who were likely to succumb to reading failure.

Studies which focus on samples of dyslexic children (e.g. Melby-Lervåg et al 2012) may give an impression that phonological deficits inevitably lead to reading problems. Snowling, though, is not alone in questioning this strong version of the hypothesis that the core deficit in dyslexia is limited development in phonological awareness, which alone is necessary and sufficient to predict a reading problem. She suggests that deficits in phonological awareness do not inevitably lead to reading problems, as there are other aspects of language skill which may help a child circumvent these. It would seem that impairment in normal language skills, by preventing such compensatory routes, increases the risk of dyslexia. Such a hypothesis effectively extends critical skills underpinning reading to include other aspects of normal language development.

2.5.1 Oral vocabulary skills and word recognition

Returning to Share's suggestion that a reader may be able to guess at a likely word based on an approximate pronunciation, it is evident that children with limited vocabularies may be at a disadvantage in this respect whilst learning to read, as many words encountered may not be known to them. Research has not always supported this view, with for instance Muter et al (2004) finding that measures of oral vocabulary did not account for the variance in word reading in 4- to 6-year-old children. It is in older children that vocabulary has a strong link with word reading. Nation and Snowling (2004) found that measures of verbal semantic skill (based on measures of vocabulary, semantic fluency, synonym judgement and listening comprehension) not only predicted word recognition in eight-year-old children concurrently, after controlling for decoding and phonological skills, but also predicted unique variance in their word recognition skills at the age of 13.

The variation in the relationship of vocabulary and reading skill across the age range might be accounted for by the simplicity of language in books designed for young beginning readers, which permits children with limited abilities to cope. Vocabulary measures start to account for variance in reading skill “only as reading develops and the range and difficulty of words children are expected to be able to read increase” (Nation and Cocksey 2009).

2.5.2 Orthographic representations based on oral input only?

Not only has it been argued that children’s oral vocabulary assists them in recognising words after they have been partially decoded, but that existing vocabulary may allow a child to build up an orthographic representation before encountering the word in print. Stuart and Coltheart (1988 p.173) raise as a possibility that “children with the necessary phonological skills” could construct partial recognition units in advance of seeing the words in print. They, however, were discussing pre-readers with some letter-sound knowledge, whereas later experimental evidence supporting this has come from work with both beginning readers with some decoding skills and those with substantially more experience.

An early study by Hogaboam and Perfetti (1978) showed that response times of skilled third graders to nonwords never previously experienced in print, but having had 18 oral exposures, were similar to those for high-frequency words.

More recent work by McKague and her colleagues with adults has demonstrated, using a masked priming lexical decision task, that the pattern of response on first encounter with non-words presented seven times orally was consistent with the subjects having an under-specified orthographic representation (Johnston, McKague and Pratt 2004), with a later study suggesting that such patterns equate with consonant frames (McKague et al 2008).

In a separate study of 6- to 7-year-old grade 1 Australian children, orally trained nonwords were read significantly more accurately than similar untrained nonwords (McKague et al 2001).

Such research does seem to suggest that mechanisms exist which could support Stuart and Coltheart's suggestion of orthographic representations based on oral vocabulary, whereby existing language skills could operate within the word recognition module.

2.5.3 Semantic factors, vocabulary knowledge and reading ability

Additional evidence that children's knowledge of a word's phonological form helps in word recognition comes from the study of English seven-year-olds by Nation and Cocksey (2009). Here children's success in an auditory lexical decision task was used as evidence of their knowledge of phonology. The words which were responded to correctly in this task were 2 to 3 times more likely to be read aloud successfully than those which were not, and this was particularly true of irregular words. Given that the analysis looked at an item-by-item relationship between phonological knowledge and success in reading words, this seems to provide a fairly convincing link between the children's oral vocabulary and reading ability.

Intervention studies have provided supporting evidence of this. Duff et al (2008) worked with eight-year-old children who had severe and persistent reading difficulties, despite having received intervention covering phonological awareness and phonics skills. A nine-week phase of training which incorporated vocabulary work alongside reading and phonological skills resulted in improvements in reading, phonological awareness and language skills. This led the authors to comment that there was a clear role of non-phonological oral language difficulties in the aetiology of reading problems.

In addition to phonological representations providing support for word recognition, semantic factors have been recognised for some time. Concrete words are more easily identified than abstract words by adults, even when possible confounding factors such as word frequency are controlled (Schwanenflugel et al 1988). Such effects extend to children, with Nilsen and Bourassa (2008) finding that kindergartners and first grade children learnt concrete words more easily than abstract words.

An important factor which will be explored in more detail in later sections is that children’s sensitivity to morphological aspects of language provides an independent contribution to reading progress even after phonological awareness-related skills have been taken into account (Apel and Lawrence 2011, Carlisle and Nomanbhoy 1993, Kirby et al 2012, Wolter et al 2009). In addition, recent work on rapid automatised naming, based on a test involving a child naming a series of consecutive letters, digits, or pictures, has led to the suggestion that perception and integration of letters and sublexical patterns also plays an important part in reading development (Norton and Wolf 2012, Wolf and Bowers 1999).

All in all, although phonemic awareness may be critical to learning to read, it forms part of a wider array of oral language and other skills which must also be in place for reading to develop normally.

2.6. Practising words: repetition and reading development

Readers, particular beginners, rely on repeated exposure to words to recognise them: “We read in two ways, the new or unknown word is scanned letter after letter, but a common familiar word is taken in at a glance” (de Saussure 1922 quoted by Coltheart 2005). The familiar word referred to here is one seen many times, which is presumed necessary for instant recognition by de Saussure, who in the above quotation described decoding of unfamiliar words and recognition by sight with a wonderful economy of words.

For explanatory purposes, a simplified dual-route model (Coltheart 2005) will be described to try to depict the role of repetition in reading acquisition. This ignores links to semantics and the phonological lexicon described in the full version (Coltheart et al 2001, Stuart 2002). In the dual-route model, ‘letter after letter scanning’, with links to the relevant phonemes, is carried out by the ‘non-lexical route’. This gives access to the grapheme-phoneme correspondences (gpc’s) that the child has learnt. The ‘word taken in at a glance’ utilises the second route specified in the model, ‘the lexical route’, which operates much faster by accessing a mental lexicon which has the orthographic representations of familiar words.

Repetition is necessary for establishing both routes. For children learning by a phonics approach, knowledge for the non-lexical route would be established by repeated practice of the sounds associated with letters and their utilisation in pronouncing and spelling words, with gradual introduction of alternative pronunciations and multi-letter graphemes. It is assumed that, during the decoding of an unfamiliar word using the non-lexical route, some letter information may be stored in the mental lexicon, although initially this may represent only partial information. With repeated decodings on subsequent exposures, this should lead to a fully specified orthographic representation, allowing the word to be recognised by sight with primary reliance on the lexical route (Stuart 2002).

Share (1995, 2004) envisages a similar process, with the use of the non-lexical route and exhaustive letter-by-letter decoding as a necessary preliminary to the formation of orthographic representations. The number of repetitions required to establish such representations varies with the age and skill of the reader (Ehri and Wilce 1983) and the characteristics of the words (Manis 1985).

Later sections of this review will provide more detail on the variation in repetitions in different studies. The point being made here is relatively simple, though: both lexical and non-lexical routes depend on repeated exposure of words to automatise word recognition and application of gpc’s.

2.6.1 Level of repetition of words in text: a critical parameter for reading development with long-term relevance to word recognition

The link between repetition in the development of decoding skills and the establishing of orthographic representations has been described. In addition, in discussions of the regularity effect, it was made clear that only low-frequency irregular words (i.e. those repeated in text rarely) are recognised less accurately than similar frequency regular words. Thus, even for competent adult readers, level of repetition still influences the accuracy with which words are read. This is true of morphological factors in word recognition, where adults respond to derived words whose stem appears frequently faster and more accurately than to those whose stems are repeated rarely (Feldman and Basnight-Brown 2008, Verhoeven and Carlisle 2006). Yet level of repetition, for all its widespread and long-term effects, has been subject to minimal research when it relates to the level of repetition required for beginning readers to learn words. The sections which follow attempt to summarise the relatively few studies located which provide background to the dissertation research.

2.6.2 Studies used for evaluating level of repetitions required to learn words

The studies used in the critical literature review to evaluate repetitions needed to learn words are those where words or nonwords are presented several times until the child can identify them accurately and relatively quickly, "taken in at a glance" using de Saussure's words.

These studies fall into two main groups, orthographic learning experiments where children have to demonstrate evidence of recalling the orthography of the practised words or nonwords, and training studies where children are expected to learn a set of words to a given criterion of accuracy and/or speed.

Orthographic learning studies accept a variety of evidence that children have learnt the orthography of the words. In some they are expected to respond faster to a word or nonword presented several times than to a pseudo-homophone of the previously presented item on its initial presentation. The logic of the approach is that, as both the practised word and the pseudohomophone are of similar length and identical pronunciation, the speed advantage demonstrates that the child is responding to the orthography of the practised word, so some form of orthographic representation has been set up.

This type of study, originated by Reitsma (1983), has made a significant impact in suggesting that lexical entries are created after very few representations and is frequently quoted in the literature. For instance (Ehri 1999 p.94) commented: "According to Reitsma's (1983) study, four practise trials may be sufficient for readers to retain information about sight words in memory."

That study is described in some detail in the sections which follow. It is the only non-English research reported. Given the extreme inconsistency of English orthography, the Reitsma work with Dutch children, as will be argued later, may have limited relevance to the development of orthographic representations in English, and hence studies have been selected for children learning to read

English. Reitsma's work, though, is often quoted when discussing reading development in English, and its seminal status seems to justify its inclusion.

Later orthographic learning studies assessed orthographic knowledge by requiring children to identify the practised word in an 'orthographic choice task', where it is presented alongside a pseudohomophone and visual foils created by making minor changes to letters in the practised word. Again, correct selection of the practised word indicates some knowledge of the word’s orthography. Some studies have included assessments of both speed of recognition and orthographic choice and, on rare occasions, a spelling test.

2.6.3 Training studies

Training studies normally require children to recognise a group of words with 100% accuracy, on two separate occasions, although with very young children this does not always occur. Some studies incorporate a criterion of speed as well as accuracy. For example Ehri and Wilce (1983) aimed at children responding as quickly to a word or nonword as to a single numeral. In the case of older children two of the studies expected children to attain a speed of response equivalent to that demonstrated with high-frequency words.

2.6.4 Minimum repetitions used in teaching – a brief note

The orthographic learning studies and some of the training studies measured the minimum number of repetitions required for children to learn words. Some caution is needed here in presuming long-term learning, as there is evidence, which will reported in detail after the studies have been described, suggesting that minimal repetitions may well reduce the durability of such learning (Lemoine et al 1993).

2.6.5 Orthographic learning studies

In this section, Reitsma's original experiment is described and discussed. For reasons made clear in the discussion, the results of this, a study of Dutch children, have not been used as a guide to repetitions needed for learning words by children learning to read English. Five studies of children in America, Australia and the UK are used for this purpose. A French study is used, not to evaluate repetitions, however, but to raise some questions about the significance of successful recognition of target words in orthographic learning experiments. A summary has been provided of the studies in English, followed by a description and discussion, part of which relates to the French research.

2.6.6 Reitsma's seminal research

2.6.6.1 The study

Reitsma (1983) conducted a training study using 18 Dutch first graders with a mean age of 7 years 1 month. This took place in February, after they had received about 6 months of formal training in reading. Twenty words were selected that were likely to be known and understood by the children in their spoken form, but not likely to have been read before. Words ranged in length from 4 to 10 letters; five were monosyllables, 14 had two syllables, and one had three syllables. Pseudohomophones were created by making graphemic alterations which did not change the pronunciation, viz. *zeilen –zijlen, fabriek – vabriek, kauwgom – kougom*, etc. Pairs of meaningful sentences were made containing either a word or its pseudohomophone, creating a set of five cards with two sentences on each. Each child read three of the cards, one card was read once, one twice and the third three times. In addition, the target words from one of the cards not shown to the child were mentioned by the experimenter, and the child was queried about their meaning and asked to put them in meaningful sentences; and the two words on the final card were not mentioned at all. These last two conditions represented 'oral' presentation only and control words respectively.

The training sessions took place on two successive days, with practice on particular target words spaced as much as possible within the sessions. Three days after the last practice session, each subject was presented with the 20 words in both standard and pseudohomophonic versions on a computer screen, and asked to read them, as quickly and accurately as possible. Naming latencies and errors were noted. Error rates for words not seen before were low: Reitsma quotes a mean error rate of 0.125, which would translate to an accuracy rate of 87.5%. Analysis of the latency data revealed that reading latencies decreased systematically with increasing experience with the words, and that only words in standard spelling read four or six times differed significantly in speed from the unfamiliar alternative spelling. The conclusion drawn was that a short training of relatively unfamiliar words had a positive effect on the speed of reading the same words again a few days later.

2.6.6.2 Citations

Reitsma’s (1983) evidence suggested that even first graders could retain sight words in memory after reading the word as few as four times, and this is widely quoted in the literature as demonstrating that very few exposures are required for children to learn them. Apart from Ehri's (1999) citation reported earlier, Adams (1990 p.361) cites it as evidence for the rapid acquisition of sight vocabulary, which she describes as 'remarkably spongelike', and Juel and Minden-Cupp (2000) mention it in an article on instructional strategies, again suggesting minimal exposures would allow words to be learnt. Menon and Hiebert (2005), although discussing it in relation to repetition needed in text for beginning readers, raise the point that it may not be entirely applicable:

> Reitsma's study does not shed light on the number of repetitions required by students at the early stages of reading acquisition, as the first graders in the sample had been selected for making typical reading progress over six months of reading instruction. (p.16)

But even here there is an implication that as few as four repetitions might be sufficient for children after six months.

2.6.6.3 Critique

2.6.6.3.1 Questions regarding durability of learning

Reitsma indicated that, although there was a significant difference between the speed of reading words practised four times and their pseudohomophones, the children read words practised six times faster than those read four times. With speed still increasing, it is not clear that children had reached an asymptote in the benefits they were receiving from additional repetitions. In later discussion of Lemoine et al's (1993) research, it will be argued that children may need to experience considerably more than minimal repetitions for word learning to be durable.

2.6.6.3.2 Dutch – a more transparent orthography

Seymour et al (2003) in a cross-linguistic study of 12 European languages, including English and Dutch, considered the latter to have a more transparent orthography, with higher decoding accuracy on monosyllabic nonwords after one year of instruction (90.48%) than English after two (74.26%), with children after one year of instruction in English only reaching an accuracy rate of 40.36%. It must be borne in mind that the younger children learning to read English had a mean age of 5.59 years against the Dutch 6.97 years, and immaturity no doubt played a part in slow progress in English. However, Seymour et al felt this was not the major cause of the poor decoding accuracy. Spencer and Hanley (2004) compared similar-age children learning to read Welsh, another language with a transparent orthography, with those learning English, and found a clear advantage to the Welsh readers at the end of the first year of instruction. Hence transparency is a significant factor in the pace of learning even when age is controlled.

The Dutch children in Reitsma's study read words on initial presentation with 87.5% accuracy. Certainly for children in the UK with the same level of reading experience, viz. six months, decoding accuracy could be predicted to be far lower. In Seymour et al's study, the accuracy of children learning English after one year's instruction, for a sample of familiar content words, was 32.59%. The mixture of both the language and age differences must undermine any assumption that Reitsma's results can be used as a basis for estimating repetitions required for sight word learning in the UK.

Differences in orthography are also felt to influence the age at which children begin to acquire orthographic representations. Thus Share (2004) found first graders learning to read Hebrew, a language with a very transparent orthography (at least in the fully-vowelised version used in beginning readers' books), showed virtually no orthographic learning, despite accuracy in decoding being very high (93%), and it was not until second grade, when children had substantially more print exposure, that such learning became apparent. At that point their orthographic learning seemed more robust than that of children learning English (Nation et al 2007).

Given the complex relationship between orthography and orthographic learning, studies in this review to evaluate repetitions required to establish orthographic representations have relied on evidence from children learning English.

2.6.6.4 Summary

The minimal level of exposure in the Reitsma study, and the lack of a delayed post-test, raise questions about durability of learning. Its relevance to children learning English cannot be presumed, given the different language and orthography, and even less so to children in the UK with the earlier age of commencement of schooling. Hence its use in the literature to suggest that very few repetitions are required for words to become sight vocabulary with its assumption of 'lasting' memories must be considered questionable.

2.6.7 Orthographic learning studies – recent research

The next section is introduced by Table 2.1 which provides a summary of all the orthographic learning studies of English which have been reported in the review. These are described and discussed immediately after a brief introduction to the experimental design used.

Table 2.1: Summary of rapid orthographic learning studies with English-speaking children

Study	Country and participants	Stimuli (All contain regular vowel digraphs)	Number of ex-posures	Interval before test	% (number) correct on orthographic choice out of 4 (or 3*)	Comparison: speed to recall targets versus homophones	Accuracy of reading targets during test
Cunningham (2006)	USA 1st grade	8 real words (7 monosyllables of 5 or 6 letters, 1 two-syllable word of 7 letters) 8 pseudo-homophones (7 monosyllables of 4 to 6 letters, 1 two-syllable of 7 letters)	6	3 days	49.29% (not stated)	(Not tested)	83.6%
Cunningham et al. (2002)	USA 2nd grade	10 pairs of mono-syllabic nonwords, 4 to 6 letters. One target repeated 6 times in a text passage of 133-234 words read aloud	6	3 days	74.70% (not stated)	Significantly faster p<0.025	74%
Bowey and Muller (2005)	Australia 3rd grade 7y2m-9y9m (m=8y1m)	12 pairs of mono-syllabic 4 letter nonwords, one target repeated 4 or 8 times in a text passage of 110-149 words read silently	4	immediate	70.33% (4.22/6)	Significantly faster p<0.001	Not relevant (silent reading)
			4	6 days	51.17% (3.07/6)		
			8	immediate	82.67% (4.96/6)		
			8	6 days	60.17% (3.61/6)		
Bowey and Miller (2007)	Australia 3rd grade m=8y2.6m	10 pairs of mono-syllabic nonwords, one target repeated 6 times in a text passage of 106-142 words read silently	6	immediate	72.4%* (3.62/5)	Significantly faster p<0.001	Not relevant (silent reading)
			6	2 days	50.8%* (2.54/5)		
Nation et al. (2007)	England Year 3 m=7.77y	9 pairs of mono-syllabic nonwords, one target repeat-ed 1, 2 or 4 times in a text passage of 106-142 words read aloud	1	1 day	37%	(Not tested)	78%
			1	7 days	27%		
			2	1 day	60%		
			2	7 days	40%		
			4	1 day	63%		
			4	7 days	63%		
	England Year 4 m=8.81y	ditto	1	1 day	36%		
			1	7 days	33%		
			2	1 day	33%		
			2	7 days	42%		
			4	1 day	61%		
			4	7 days	45%		

2.6.8 Recall of orthographic detail of nonwords: Share's rapid orthographic learning approach

Reitsma's paradigm of comparing children's abilities to read words and their homophonic alternatives was altered by Share (1999) to using nonwords, so as to avoid the possibility of the participants having seen the targets elsewhere. The only exception to this in the studies analysed here is Cunningham's study of 1st grade children, where real words were used. This is described in more detail in the next section. To make the learning similar to that found in normal reading, Share's paradigm makes use of short stories containing the stimuli, rather than embedding them in single sentences, as in Reitsma's original research.

Nonwords, where used in the stories, were used as the name of a flower, animal, town, etc., exposed a set number of times and, after the children had read the stories, tested in contrast with identically pronounced pseudo-homophones on a variety of measures to assess orthographic learning. In addition, whereas Reitsma provided corrective feedback during the training sessions, Share did not, allowing him to verify his self-teaching theory. Share (1999) studied children learning to read Hebrew, and his results are therefore not presented here.

2.6.9 Rapid orthographic learning of real words

Cunningham (2006) followed the paradigm developed by Share (1999), using real words as targets with 1st graders, thus to some extent paralleling the original Reitsma (1983) age group and approach. Her subjects were of a similar age (mean = 7.10 years, s.d. = 0.31), although they were tested slightly later in the school year. Words were selected which were in the children's oral vocabulary, knowledge of their meaning being subject to a pre-test, but which were unlikely to have been automatised in print (e.g. *bored, chews, course, groan, pause, piece, prince* and *thirsty*).

Pseudohomophones were constructed as alternatives, e.g. *bored/bord, chews/chooze*, etc.; both the real word and the homophonic alternative were used as targets. There were eight targets, which were presented in short stories ranging in length from 99 to 120 words, each target appearing six times. Half the children read the story as a cohesive text, the other half with words scrambled randomly. This was to assess the impact of contextual support both on accuracy of reading and on orthographic learning.

The children read the texts aloud with no help from the researcher, split between two sessions. The readings were tape-recorded; accuracy was noted and the children were given post-tests three days later, including orthographic choice. This involved the children choosing between the word (*chews*), the pseudohomophonic alternative (*chooze*), a variant of the target word with one letter changed for a visually similar alternative (*chaws*) and the target word with two adjacent letters transposed (*chwes*).

Accuracy of reading the words was high: 83.6% in the story and 67.0% in the scrambled version. The percentage of correct identifications made in the orthographic choice task was 49.29% in cohesive text and 46.43% in the scrambled condition. Thus after reading four new words six times, on average half were recalled accurately after a delay of three days, indicating that rapid orthographic learning can occur among young readers of English despite the known slow development of decoding skills.

This group of seven-year-olds, after around six months of reading, obtained a far higher decoding accuracy, when reading words in scrambled text (67%), than the sample of children learning to read English in the Seymour et al study (2003). The latter, with a similar length of reading experience at age 5½, obtained accuracy rates of only 32.59% on individual word reading of a sample of familiar words. It thus seems highly probable that the much younger age level of Seymour et al's sample of children had had a significant impact on their learning, reducing its effectiveness despite equivalent time with reading instruction. This may also question the likelihood of children in the UK retaining words after low levels of repetition. However, with the later age of commencement of schooling, the American children in the Cunningham study, with six repetitions of words, did successfully retain orthographic information on some words.

The comments made previously, however, on lack of evidence of durability of learning for Reitsma's original study would equally apply to Cunningham's.

2.6.10 Rapid orthographic learning of nonwords

2.6.10.1 American children

Cunningham et al (2002)

This was the first study to alter Share's adaptation of the Reitsma paradigm for use with children learning to read English. A sample of 34 2nd graders from a predominantly middle-class Californian elementary school read short stories containing target nonwords at the end of the school year (May/June). There were ten stories; each contained the target nonword six times. They varied from 133 to 234 words in length, with the vocabulary selected so as to cause no difficulty to a second-grade child. There were ten pairs of monosyllabic, homophonic nonwords varying from four to six letters in length (e.g. *yait/yate, slurst/slirst*, etc.); all had pronunciations which were entirely predictable using standard grapheme-phoneme correspondences. Children read five stories in each of two separate training sessions, on each occasion followed three days later by the test tasks. There was an interval of seven days between the two training sessions.

Stories were read aloud to an experimenter who, apart from reading the title to the child, gave no further help. Each session was taped and timed. The accuracy of pronunciation of the target items was recorded online by the experimenter.

The children's memory for the target items was assessed using three tests. The first was an orthographic choice test in which they had to select the target (e.g. *yait*) they had seen from a choice which included its homophone alternative (*yate*) and two other foils in which either a letter was substituted (*yoit*) or two letters were transposed (*yiat*). The children were then asked to spell the target items they had seen, and finally there was a naming task where latencies to speech onset were timed and accuracy of pronunciation was noted. The tests were always given in this order.

In the initial reading of the stories, the maximum possible score was 60 (10 stories each with one target exposed 6 times); the mean number of correct pronunciations was 44.4 (s.d. = 12.9). Thus decoding accuracy was 74% (44.4/60). Three days later, the children achieved similar levels of accuracy in the choice task (74.7% correct) and the spelling task (70.3% correct), and a slightly higher level in the final naming task (around 80%). Performance in the last task may have benefited from the recent reminders of the targets in the two preceding tests. Even so, the accuracy level of decoding accuracy attained by these second graders was considerably lower than Reitsma's children after six months of instruction, where the mean of the decoding accuracy for words exposed six times was 98.4% (mean error rate = 0.016). Some of this difference may, however, be attributable to the use of real words in the Reitsma study compared to the nonwords used with the American children.

It is apparent, though, that in the Cunningham et al study, after six exposures in the story, a substantial amount of orthographic information was still retained after a delay of three days, with around three-quarters of words correctly identified in the orthographic choice task.

2.6.10.2 Australian children

Variations on this paradigm have been carried out in Australia by Bowey and her colleagues. Bowey and Muller (2005) felt that the requirement that the children read the text aloud, by making phonological decoding obligatory, left as an open question whether self-teaching would take place in silent reading. They therefore altered the design so that children read the twelve passages silently. Third graders ranging in age from 7 years 2 months to 9 years 8 months took part. On a word identification test (Woodcock 1987) their reading ages ranged from 7 years 4 months to 10 years 5 months. Twelve four-letter regular nonwords were used as targets, with comparable pseudohomophones (e.g. *ferd/furd, cale/cail*); again, all had entirely predictable pronunciations. Accuracy of pronunciation of nonwords contrasted with pseudohomophones, and speed of reading, were assessed at post-test, on the assumption that an advantage in speed of the target nonwords would indicate they had been phonologically decoded during the silent reading task. This proved to be the case, with a highly significant increase in speed of reading of the lists of target nonwords relative to their pseudohomophones ($p<0.001$).

Bowey and Muller also varied the number of repetitions, with some targets repeated four and others eight times, and tested orthographic learning both immediately and after a delay of six days. Results indicated significant learning after four exposures with an increase in learning after eight exposures. Testing after the six-day delay showed that less information was retained than on immediate testing: the children recalled on average 70% of targets after four repetitions (4.22 out of 6) and 83% (4.96 out of 6) after eight repetitions. These figures dropped to 51% and 60% respectively after a six-day delay, giving three to four words learnt out of six.

A further study of silent reading carried out with children of a similar age and ability by Bowey and Miller (2007), using six repetitions of similar nonwords in ten stories, led to a 72% retention rate on immediate testing and 51% after a two-day delay.

2.6.10.3 English children

A study carried out in England by Nation et al (2007) evaluated learning after 1, 2 and 4 repetitions of words in stories using children from Years 3 and 4. The exposure levels were selected to replicate an experiment carried out by Share (2004 Experiment 1) with children learning Hebrew, where significant learning was obtained after a single exposure. There were 20 children from Year 3, mean age 7.77 years, whose average standard score on the word subtest of the Test of Word Reading Efficiency (TOWRE) was 108.50, and 22 from Year 4 with a mean age of 8.81 years and average standard score on the word reading subtest of 106.44. They read six stories, and were tested on information retained following a 1-day or 7-day interval. This was assessed using orthographic choice only; hence, although it was clear when orthographic detail was retained, there was no information on accuracy of pronunciation or speed of reading aloud on the post-test. The nonwords and pseudohomophones were taken from the Bowey and Muller (2005) study.

There was evidence of orthographic learning at all exposures, with more learning for more exposures, and a higher number of correct choices made after one day than after a delay of seven days. These ranged from 37% correct choices after one exposure to 63% after four exposures for Year 3, with these percentages showing results of 27% and 63% after a seven-day interval. Equivalent figures for Year 4 were 36% and 61%, dropping to 33% and 45% after seven days.

As with Share’s original experiment, there was an effect for orthographic learning after just one exposure of the word. However, whereas Share had obtained no significant change in the amount of orthographic learning after 1, 2 or 4 exposures, and no change between the effects obtained on immediate assessment and after a delay of seven days, Nation et al obtained significant effects of exposure and a loss of learning after a delay. They attributed this to the depth of orthography in English with its known impact on decoding accuracy: “… because initial decoding in children learning to read English is more fragile, more exposures provide more decoding opportunities, which in turn lead to more orthographic learning” (Nation et al 2007 p.79).

Accuracy of reading the target nonwords was not feasible in the silent reading variant of the Bowey and Muller (2005) study, but the figures given for reading a list of similar nonwords with identical digraphs was on average 78% (14.21 out of 18), with an identical success rate for initial reading of nonwords reported by Nation et al (2007).

It is clear from the studies in Australia, England and the United States with children aged 7 to 9 that, even with two to five years’ reading experience, percentage accuracy in reading nonwords containing regularly-pronounced vowel digraphs remained in the 70%s, which reinforces the picture of slow development of decoding in English.

2.6.10.4 French children

A study by Sprenger-Charolles et al (2003), although based on French, a more transparent language from a reading viewpoint, casts a certain amount of doubt on implicit assumptions that evidence of orthographic learning necessarily leads to the immediate use of such representations in word recognition. French children participated in a four-year longitudinal developmental study of reading, silent reading and spelling from four months after reading instruction commenced in grade 1 until the end of grade 4. Part of the study looked at silent reading, using a semantic categorisation task in which children were asked whether a word displayed on the computer was a member of a particular category (e.g. 'Is it an animal?'). Categories included animals, colours, transport, etc.

Children were presented with words drawn from two different lists on two consecutive days. Each list contained a mixture of 'fillers' which were 14 real words and the 'targets', five pseudohomophones and five visual foils based on ten high-frequency words not used in the lists. Overall children responded to 28 real words and 10 of each target. The real-word fillers were similar in frequency, length and spelling patterns to the high-frequency words. The pseudo-homophones had one additional letter or one less (e.g. *auto, *oto, vélo, *vélau*) than the high frequency words on which they were based, whereas the visual foils were the same length as the original word with a single letter changed (e.g. *auto, *outo, vélo, *véla*). Word shape was thus better preserved in the visual foils. Despite this, at the end of grade 2, significantly fewer errors were made in accepting visual foils as real words in the semantic categorisation task (5.19 out of 10) than pseudohomophones (7.52 out of 10).

On a separate orthographic choice task, where children were asked to select the correctly spelt high-frequency word presented together with its pseudo-homophone and visual foil, accuracy was 85.71%. This task was always presented after administration of the semantic categorisation task, and was taken as providing strong evidence that children had orthographic representations of the real words.

Neither the orthographic choice task nor the semantic categorisation task involved reading aloud. In the authors' view, the reading element of both tasks could be carried out purely on a visual basis, and any evidence of phonological processing was therefore taken "as an indicator of mandatory involvement of phonological processing in (the children's) written word processing" (Sprenger-Charolles et al 2003 p.196).

The very high number of errors on the pseudohomophones in the semantic categorisation task (7.52 out of 10) was therefore taken as clear evidence of strong reliance on phonological processing, even though orthographic representations seemed to exist for the real words with the same pronunciation. Certainly for French children during silent reading in the semantic categorisation task, the existence of orthographic representations of high-frequency words did not seem to prevent phonological processing providing a stronger contribution to word recognition.

It is true that results might be different for beginning readers of English, as there is evidence of their being more sensitive to orthographic information than readers of more transparent languages (Share 2004). There is, however, evidence that readers of English show an early reliance on phonological processing, for instance by making errors in accepting homophones as correct in sentences – **I no your name* (Doctor and Coltheart 1980) – and in showing a significant regularity effect on high-frequency words, at least up to grade 3 (Backman et al 1984).

Hence Sprenger-Charolles et al’s conclusion that phonological processing is only gradually replaced by orthographic processing, despite evidence of orthographic representations, might well equally apply to English, particularly in young readers.

2.6.11 Analysis of studies of orthographic learning in English

From these studies building on Reitsma's original research, it is clear that rapid orthographic learning can occur in English at a relatively early stage, and in slightly older children some effects can be seen with just one exposure (Nation et al. 2007). The studies also showed that learning increases with more repetitions (Bowey and Miller 2007, Bowey and Muller 2005, Nation et al. 2007). Accuracy of recall of orthographic information on targets varied from a maximum of 74.7% after six exposures in Cunningham et al’s study of second graders, to a minimum of 33% after just one exposure in Nation et al’s research with English third and fourth years. There was also an age effect, with the first graders in Cunningham’s (2006) study only obtaining 50% accuracy rate after six exposures, compared to the 74% attained by second graders with a similar level of exposure in the Cunningham et al (2002) research.

In virtually all studies where delayed recall was used there was a clear loss of information compared to immediate assessment, the only exception being the nonwords exposed four times to the Year 3 children in Nation et al's study.

The research paradigm involves the careful selection of words used to construct the stories for the children so as to cause no recognition difficulties for their age group. This left children with the task of learning a single unfamiliar word in fairly easy text which, as pointed out by Hiebert and Martin (2009), may not reflect the normal reading experience of young readers. In these circumstances orthographic information clearly was retained. However, with more typical reading matter, and perhaps several unfamiliar words in a short passage, and the known loss of information with even slightly delayed recall, rapid learning sufficient for long-term retention may require more exposure than has been used in orthographic learning experiments.

The literature, though, could lead one to believe minimal repetitions are quite sufficient for this purpose. Cunningham (2006 p.58), for instance, comments, based on her study of first graders: "After a letter string has been decoded successfully, a small number of future successful encounters with the word are sufficient to add the word to the reader's orthographic lexicon."

Evidence, though, of sufficient familiarity to succeed on occasions in the orthographic choice task after a three-day delay, after very few repetitions, provides a limited basis for suggesting the changes in orthographic processing which seem to be implied here. The French study, which used high-frequency words and obtained a high success rate on orthographic choice, showed that, if there were entries for those words in the orthographic lexicon, these did not obstruct the child from erroneously identifying pseudohomophones as representing real words and hence, by inference, relying on phonological processing.

Even though this result was based on a more transparent language than English, it must raise some doubts as to whether orthographic representations in beginning readers of English based on very limited exposure to words have all the properties generally claimed for sight vocabulary, one of which is ‘precision’, i.e. that the lexical entry should uniquely identify a word for recognition purposes (Perfetti 1992), which was not true of French children at the end of grade 2 or grade 3.

In addition, there are assumptions about lasting recall of sight words. Although it is apparent in the studies of young readers that the beginnings of representations have been set up, questions on their completeness and robustness for the long term seem to remain, and will be subject to further discussion.

2.6.12 Training studies used to evaluate repetitions required to learn words

As has been discussed in the introduction to the orthographic learning studies, research which aimed at children learning words to sight recognition levels was used for evaluating repetitions required for learning vocabulary, as there is an assumption that the entries in the mental lexicon are long-lasting. All but one of the training studies described in the next section meet this criterion. The exception, the Wright and Ehri (2007) study, was included as there was a paucity of studies dealing with young readers from the United States.

The two studies of English beginning readers (Stuart et al 2000, Dixon et al 2002) stand out for the very young age of the children assessed. The results of Seymour et al's (2003) assessment of similar age children, coupled with that of Spencer and Hanley (2004), suggest that immaturity may have a significant effect on the rate of reading progress in English and, although the research is relevant to that carried out for the dissertation, it is interesting to have results for older American children in the very early stages of acquisition.

Studies from the United States which made use of simplified spellings (e.g. Ehri and Wilce 1985, Ehri and Robbins 1992, Ehri and Saltmarsh 1995) were avoided, as it was difficult to assess the impact of the modification on learning relative to normally spelt words. Although the Wright and Ehri study also used modified spellings, they seemed sufficiently close to normal to include the results, despite the inclusion of a few words which have illegal initial double consonant letters.

This section begins with a summary of the studies reviewed (these are all listed in Table 2.2), followed by detailed description and discussion.

Table 2.2: Summary of training studies with English-speaking children

Study	Country and participants (in increasing order of age)	Stimuli	No. of exp's	Sub-group	Interval before test	No. of words passed* (out of total)
Stuart et al. (2000) Study 1	England 5-year-old reception children 2 to 3 months after starting school 2 skill groups: good graphophonic skills (GP+), poor graphophonic skills (GP-) Book presentation only	16 words embedded in text: 8 nouns, 5-7 letters,1 or 2 syllables; 8 function words, 5-9 letters, 1-4 syllables Non-decodable by children	36	GP+	immediate	6.8/16
				GP+	1 month	4.8/16
				GP-	immediate	3.1/16
				GP-	1 month	2.4/16
Stuart et al. (2000) Study 2	England 5-year-old reception children 6 to 7 months after starting school 2 skill groups: good graphophonic skills (GP+), poor graphophonic skills (GP-), crossed by 3 method groups: flash cards, book presentation, both	8 nouns, 5-7 letters, 1 or 2 syllables Non-decodable by children	32	GP+	immediate	5.31/8
				GP-	immediate	3.08/8
				flash cards	immediate	6.67/8
				books	immediate	2.9/8
				both	immediate	3.6/8
Dixon et al. (2002)	England 5-year-old reception children, three groups: segmenting initial and final phoneme (PA1), segmenting initial phoneme (PA2) and no segmentation (PA3)	10 two-syllable concrete nouns presented on flash cards. Non-decodable by children	24	PA1	immediate	9.6/10
			36	PA2	immediate	4.43/10
			36	PA3	immediate	3/10
Wright and Ehri (2007)	USA Kindergartners and 1st graders, two groups: Full Phase (FP), capable of reading nonword CVCs, Partial Phase (PP), cannot read nonword CVCs	12 short regular CVCs (though some had illegal initial double consonants), presented on flash cards.	4	FP	immediate	12/12
			7	PP	immediate	12/12

Key: *'Passed' = stimuli read at same speed as numerals (Ehri and Wilce) or high-frequency words (Hogaboam and Perfetti, Manis) or number of correct responses (otherwise)

Table 2.2: Summary of training studies with English-speaking children (cont.)

Study	Country and participants (in increasing order of age)	Stimuli	No. of exp's	Subgroup or word type (Manis)	Interval before test	No. of words passed* (out of total)
Ehri and Wilce (1983)	USA 1st and 2nd graders aged 7 and 8 years, less skilled (LS) group scoring at 1st and 2nd grade level, the skilled (SK) group scoring at 3rd and 4th grade levels.	4 nonwords (same in each list), alongside 20 real words (varied across lists)	18	LS	immediate	3.64/4
			18	SK	immediate	3.92/4
Hogaboam and Perfetti (1978) Experiment 3	USA 3rd graders, two groups: skilled (SK) and less skilled (LS)	3 two-syllable easily pronounce-able nonword CVCVCs presented alongside 9 more	3	SK	immediate	3/3
			6	LS	immediate	3/3
Hogaboam and Perfetti (1978) Experiment 2	USA 4th graders 2 groups, skilled (SK) and less skilled (LS), immediate and delayed post tests.	6 two-syllable easily pronounce-able nonwords CVCVCs alongside 6 presented aurally	15-18	SK	immediate	6/6
			15-18	SK	10 weeks	6/6
			15-18	LS	immediate	6/6
			15-18	LS	10 weeks	6/6
Manis (1985)	USA 5th and 6th graders	24 words, 8 low-complexity regular (LCR), 8 high-complexity regular (HCR) and 8 irregular (I)	4	LCR	immediate	8/8
			6-7	HCR	immediate	8/8
			6-7	I	immediate	8/8

Key: *'Passed' = stimuli read at same speed as numerals (Ehri and Wilce) or high-frequency words (Hogaboam and Perfetti, Manis) or number of correct responses (otherwise)

2.6.13 Studies with English reception-age children

2.6.13.1 Stuart et al's (2000) Studies 1 and 2

Stuart et al's (2000) two studies are the only ones which set out to simulate the normal teaching procedure by which children in the study were taught new vocabulary. They mimicked the teaching approach used in the schools where the studies were conducted, and used words which were too difficult for the children to fully decode using the spelling-sound translation rules they had learnt so far (if any), with the intention of forcing the children to use the ‘lexical route’ rather than decoding the words by application of gpc’s.

The first experiment used children in their first term who could not read any words in the British Ability Scales Single Word Reading Test (Elliott 1996). They were split into two groups, one with good initial sound segmentation and sound-to-letter mappings, the other containing children who performed poorly on both these tests. The groups were referred to as the ‘good graphophonic skills group’ and ‘poor graphophonic skills group’ respectively.

The children were taken in pairs to a quiet place, and sat either side of the trainer. Here they were introduced to ‘special books’ from which they were going to try to learn words. The trainer read the books pointing to each word as she said it. The words were included in simple sentences alongside colourful illustrations. The target words were printed in red; the remainder in black. When the trainer came to a red word, she pointed it out to the children: “Oh look, here‘s one of the red words for you to learn. This word says … Can you read it?” The style of the presentation was one the school had developed to encourage children to read for meaning, with the adult initially taking the lead role until the child was sufficiently independent to read alone.

There were nine training sessions during November and December, starting two months after the children had begun school. The aim was to teach 16 target words, split evenly between two books. Each book contained eight targets repeated four times, so over the nine training sessions the children saw each target 36 times. Words varied in length from 5 to 9 letters; 8 were nouns, 8 were function words; half were regular and half irregular. The nouns varied in length from five to seven letters, and contained one or two syllables (e.g. *glove, haddock*); the function words varied from five to nine letters and from one to four syllables (e.g. *quite, everybody*).

The use of long words which the children were unlikely to be able to decode by the non-lexical route, despite not being out of line with vocabulary in their normal reading books, would make them difficult to learn. Moseley (2004), in a large-scale study of Year 1 children, found word length to be the most significant factor for predicting children's reading accuracy.

The children in Stuart et al's study were tested on completion of the training in December, and on a delayed post-test at the end of January. They were shown the words on flash cards in random order and asked to name them. On the recall task immediately after the training, the overall mean was 4.95 (s.d. 3.09). Thus on average children learnt only 5 of the 16 target words. The children with 'good graphophonic skills' learnt around 7 words (mean 6.8, s.d. 2.6), whereas those with 'poor graphophonic skills' learnt around 3 (mean 3.1, s.d. 2.4). On the delayed recall tests in January, the respective scores were around 5 (mean 4.8, s.d. 2.4) and 2½ (mean 2.4, s.d. 2.3) – these results are discussed further in the section on long-term retention. Overall, nouns were easier to learn than function words, but there was no significant effect of regularity, which was to be expected if all words were too difficult for children to decode. The results clearly indicated that, at the earliest stages in learning to read, a very high level of repetition was required for children to learn some of the vocabulary presented in their reading books.

The second training experiment, carried out at different schools later in the reception year, was possibly a more relevant comparison for the younger children in the orthographic learning experiments, who had all experienced at least six months of formal education. The study took place in March and April, by which time participants would have received a similar length of tuition to those in the Reitsma (1983) and Cunningham (2006) studies.

In this study, children were taught the eight nouns used in the first study by a range of contrasting methods. Again the subjects were screened on the British Ability Scales Single Word Reading Test to select complete non-readers. These were tested as in the previous study on graphophonic skills and split into two groups, a skilled group (GP+) and one with poor skills (GP-). This formed the basis for an analysis comparing children in the GP+ and GP- groups being taught with a mixture of methods. For comparison of the methods, three groups of 10 children were formed, using as far as possible equal numbers of GP+ and GP- children so that the groups had similar levels of ability overall. There were four exposures in each of eight training sessions, making a total of 32 exposures in all.

After the final session, the children were asked to name the words presented in random order on flashcards, for all methods. The average number of words recalled was 5 (mean 5.31, s.d. 2.79) for the children with good graphophonic skills, and 3 (mean 3.08, s.d. 2.84) for those with poor skills. The group taught using flash cards alone recalled more words (mean 6.67, s.d. 2.19) than the other groups: mixed methods group, mean 3.60 (s.d. 3.06), and book only, mean 2.90 (s.d. 2.42). Flash card training thus resulted in more than twice the number of words recalled as for book exposure alone, for the same number of repetitions of the target words.

All the remaining studies reported in this section used flash card presentation as part of their training. In view of the far higher number of words recalled using this method compared to book exposure, it is clearly substantially more effective for teaching purposes. Consequently, the numbers of repetitions reported for attaining criterion in studies which used flash cards for training are underestimates of the repetitions likely to be needed to attain similar results from book reading.

2.6.13.2 Dixon et al (2002)

Dixon et al (2002) carried out a training study using flash cards with English reception children. Three groups of 10 children varying in segmentation ability were compared. The least skilled group could not segment at all, the second could segment only initial phonemes, and the third could segment both initial and final phonemes. They were taught to read 10 two-syllable six-letter regular words, all nouns, using flash cards. The 10 words included several which incorporated grapheme-phoneme rules not normally learnt in the reception year.

Generally such children are likely to be restricted to words with short vowel sounds spelt by one letter in decoding unfamiliar words (Ehri 1991, Share 1995), but the words taught in Dixon et al included several with vowel correspondences which did not meet this criterion (e.g. *Turnip* and *Carton*). Thus, although all the words were regular, from the point of view of these subjects, some should be considered non- (or not yet) decodable.

At each session the children were shown each word four times. The intention was to stop the training once the children had reached a criterion of two training sessions in which they read all 10 words correctly. All the children in the most skilled group attained this criterion by the sixth session. The experiment was continued until fourteen sessions had taken place in all, but there were still children in the remaining groups who had not attained the criterion. At this stage the experiment was stopped. Analyses presented in the paper covered the results to the end of the 9th session, by which stage children in the most skilled group had received 24 exposures of target words. The remaining groups had received 36 presentations of targets in the nine sessions.

Dixon et al's non-segmenters, those who could not segment either initial or final phonemes, had learnt on average only two words after 36 exposures. Children who could segment initial letters had learnt around four words, and those who were known to be able to segment both initial and final phonemes had learnt 10 words to two error-free trials after 24 exposures with corrective feedback.

Looking at the overall results of these three studies it is clear that a major factor in the number of repetitions required for learning sight words is children's ability to segment phonemes. Dixon et al’s research provides clear evidence both on the increase in learning rate as children develop segmentation skills, and on the detail of representations which they can form. The children with the most advanced segmentation skills, able to segment both initial and final phonemes, were also able to reject incorrectly spelt items in a forced-choice task where errors occurred in those positions.

2.6.14 Studies with American children

The remaining studies reviewed are American and, as commented earlier, there is an age difference from the UK in the point at which children start formal education. For the children in the first grade or kindergarten, level of segmentation skill has been reported where available, whereas for the older children their chronological age has been provided.

2.6.14.1 Wright and Ehri (2007)

This study is the only one analysed here where ‘normal’ words with unusual spellings were used, as it was felt there was a reasonable similarity between the adjusted spellings and the real words. The study also made use of several normally-spelt words among the stimuli. A mixture of kindergarten and grade 1 children, around 6 years of age, were taught to read 12 short regular words using flash cards. The purpose was to evaluate the extent to which beginning readers’ sensitivity to legal and illegal orthography affected their rate of learning to read and spell words. For this reason spellings were used which involved words with double consonants in legal and illegal positions (e.g. *nutt* (*nut*), *rrag* (*rag*)). For control purposes some CVCs were also taught (e.g. *fan, wip* (*whip*)).

The children were split into two groups of 20. The more able group could decode nonword CVCs, and scored higher on a phoneme segmentation test which involved tapping for sounds heard in CVCs, CCVCs and CVCCs. These were referred to as full-phase readers. The less able group, the partial-phase readers, could not decode nonword CVCs, and were less competent at segmentation. In spelling they used initial, or initial and final consonants, but missed out the vowels. This would suggest that some individuals were capable of both initial and final phoneme segmentation on occasions. The more able group spelled most sounds in words, including correct or phonemically close vowel graphemes, again indicating reasonable segmentation skills. Both groups knew the letter sounds for more than 20 letters of the alphabet and could read some familiar words.

The partial-phase children required on average seven trials of reading words on flash cards to reach two complete error-free trials. The full-phase readers capable of reading CVCs required on average only four trials, including the two error-free trials, to reach the same criterion of success. Thus it took just two trials for these children to learn to deal with new words, even though some had illegal initial double consonant letters. All these children could read some words, so even the partial-phase readers were more advanced than those in Stuart et al's first study.

2.6.14.2 Ehri and Wilce (1983)

The lack of recent research on sight word acquisition made it worthwhile to consider older studies, even though segmentation skills were not reported at all. Experiment 2 from Ehri and Wilce's (1983) paper on unitisation speed fell into this category. It made use of 1st and 2nd graders to evaluate whether young readers can recognise familiar words as fast as they respond to individual digits, at which stage the words were considered to be 'unitised'. Two groups of readers drawn from 1st and 2nd grades were split into skilled and less skilled groups, and required to read vocabulary encountered early in their reading career and some nonword CVCs, the latter being practised 18 times over two sessions.

Despite the children being taken from the lowest reading groups in the school, they varied from the 5th to the 93rd percentile on the Peabody reading test. (Mean ages were: 1st graders, 83.8 months; 2nd graders, 95.7 months.) The authors commented that they were surprised by the range of ability, in view of the method of selection.

The less skilled group were selected so as to have grade-equivalent scores for the 1st and 2nd grades for general reading ability, the skilled group for 3rd and 4th grades. The less skilled group contained only two 2nd graders and all the 1st graders, the more skilled group contained only 2nd graders. The latter obtained a higher level of accuracy in reading CVCs than skilled fourth graders in an earlier experiment reported in the paper. For this reason their results must be considered atypical even for 2nd graders.

The less skilled group read 46% of unfamiliar nonword CVCs correctly. Segmentation skills were not reported, although the ability to read nonword CVCs is a useful indication of the ability to translate graphemes to phonemes, and places even the less skilled group on a par with Wright and Ehri's full-phase readers.

The training approach seemed a lot harder than other flash card or list reading studies. Children were expected to learn 28 words spread across 18 lists of 24 words. Target words were 12 familiar short words presented six times, and 12 familiar short words and four unfamiliar nonword CVCs presented 18 times, with some filler words to ensure a varied series and maintain the lists at 24 items. The task difficulty will need to be borne in mind when attempting to draw results of the various training studies together. Nine lists were presented on each of two consecutive training days, which were sandwiched between two days of pre- and post-testing.

The less skilled group did not attain unitisation speeds for nonword CVCs although, based on charts provided in the paper, it seems that their response latency times after 18 exposures approached their initial speed on familiar short words. These included 10 content words and one function word, all of three to four letters. On nonword CVCs the less skilled group moved from a success rate of 46% to 91%. Hence after 18 repetitions nonwords reached a speed and accuracy similar to familiar words at the outset. Nonwords could be considered equivalent to unfamiliar words not in the child’s oral vocabulary, and 18 repetitions therefore seem to have provided sufficient practice to bring them into line with the children’s existing familiar word vocabulary.

The more skilled group, composed entirely of 2nd graders, obtained unitisation speeds on CVCs after 18 exposures. The success rates were extremely high both at the beginning and end of the study, with only a minor variation (beginning 98.4%, end 98.0%). Even at the outset the children's response latency times were almost as fast as the less skilled group’s response to single digits. In terms of the definition, these children's responses both to unfamiliar CVCs and familiar words were rapid and reliable before any further training was provided.

2.6.14.3 Hogaboam and Perfetti (1978)

Another early study of repetitions required for sight word speeds was carried out by Hogaboam and Perfetti (1978, Experiment 2). Rather than matching response latency times to digits, as used by Ehri and Wilce (1983), they used the children’s speed for high-frequency words as a guide to when trained words had attained sight word level or unitised speeds. Two groups of third graders were provided with varying levels of exposure to easily pronounceable two-syllable nonword CVCVCs whose response latency time at post-test was compared to that of high-frequency words. The CVCVCs were exposed 3, 6, 12 or 18 times over three sessions on successive days, and tested on the day following the training.

The children were matched for IQ, and split into a skilled reading group scoring above the 60th percentile on the reading subset of the Metropolitan

Achievement Test, and a less skilled group scoring below the 40th percentile. The skilled group attained response latency times equivalent to high-frequency words after just three exposures, whereas the less skilled group required six. It should be noted, however, that the skilled group were very close to high-frequency word speeds for unfamiliar CVCVCs at the beginning of the study, whereas the less skilled group had to double their speed of response to attain levels similar to their latency times to high-frequency words.

2.6.14.4 Manis (1985)

For more complex regular words and irregular words, the study by Manis (1985) provides some relevant data, although this is for older children and there were some problems with the design which make clear conclusions less possible. Ten normal readers from fifth and sixth grades (10- to 12-year-olds approximately) had systematic daily exposure to four lists of 8 words varying in length from three to six letters, mostly monosyllables, with between one and three two-syllable words per list. One list comprised high-frequency words with regular pronunciations (e.g. *dog, letter*). The other lists were composed of unfamiliar words described respectively as low-complexity regular words (e.g. *nib, tassel*), high-complexity regular words (e.g. *ire, civet, scaup*) and irregular words (e.g. *loch, trough*).

Results on the low-complexity regular words were similar to the Hogaboam and Perfetti study. After just four exposures the children reached the same levels of decoding accuracy and speed as on the high-frequency words. For the high-complexity regular words and irregular words, it would appear from charts provided in the article that the speed of response converged very quickly towards the speed of high-frequency words, namely after six to seven exposures. In a similar manner, word-length effects became negligible by six to seven exposures for the entire sample of 24 words.

Thus by six to seven exposures, immediate post-testing seemed to demonstrate sight word status for the high-complexity regular words and irregular words. The mean reading grade for the subjects on the Iowa Test of Basic Skills or the Stanford Reading Achievement Test (comprehension subscale) was 6.7 (range 6.0 to 7.6). As the children were 5th and 6th graders this suggests that they were at slightly above average levels of reading.

There was, however, a problem with the design which may result in the quoted exposure levels underestimating the level likely to be needed in normal reading. Manis used an introductory session and three training sessions. During the training sessions, words were exposed three times and there was also a single exposure in the introductory session, ten exposures overall. In addition to the exposure of the target words in print, in the introductory session all three sets of unfamiliar words were defined orally and the child was required to repeat them twice.

Children were also shown an outline drawing illustrating the word. This was followed by a matching task in which the child was required to select the drawing from the full array of 24, based on the experimenter saying the word. The matching task continued until the child was able to correctly recognise 20 of the 24 words used as targets for reading. This matching task was also administered in the three training sessions prior to the words being exposed in print and timed. The article gives no details of the actual number of training trials of this type provided to the subjects, although it is clear that they will have heard the target words several times.

In the Hogaboam and Perfetti study it had been established that oral exposure on its own improved the response latency for all the children, the skilled group showing an improvement after just three exposures and the less skilled by around twelve. This demonstration that oral exposures alone can facilitate recognition in print has since been supplemented by the work of McKague and her colleagues (Johnston et al 2004, McKague et al 2001, 2008).

At the point where Manis first assessed accuracy and response latency, the children had had a minimum of three oral exposures in addition to one printed exposure. It may well have been the case that the low-complexity regular words had already reached high-frequency word speeds from this input alone at the end of the introductory session. Children's response times, however, were not measured until after the end of the first training session, when a further four print exposures had been provided alongside an unknown number of oral presentations. Similarly, although high-complexity regular words and irregular words converged on the speed of the familiar high-frequency words by six to seven exposures, there was the additional benefit of the oral training with an unstated number of repetitions.

It might therefore be considered that print exposure alone may need to be at a higher level for sight word status if there have been no prior or parallel oral presentations, moving the optimal level above the six to seven suggested. In addition, it is probable that the older children used in this study were likely to have a wider range of decoding skills than second and third graders, and to be more practised in their application of them. It is therefore possible that younger subjects would find the complex regular words more difficult to learn, and require more than the minimal levels of exposure recorded in the Manis study. Despite the fact that there were clear differences in accuracy and speed of response between regular and irregular words in the charts, the ANOVA analysis showed no significant difference. Manis, however, in his discussion, states “normal readers... pronounced regularly spelled words more quickly and more accurately than irregularly spelled words” (p.88), and this has been taken as a trend towards a regularity effect.

2.6.15 Training studies which tested for long-term retention

As can be seen from Tables 2.1 and 2.2, the only studies among the 13 listed which tested retention after more than 7 days were Study 1 of Stuart et al (2000), who tested for recall after an interval of a month, and Experiment 2 of Hogaboam and Perfetti (1978), who tested the children 10 weeks after the training ended.

Stuart et al. (2000) found that, after the delay, children with good graphophonic skills were successful on about five of the original 16 words taught, and children with poor graphophonic skills on only about 2½; both groups had scored higher on the immediate post-test (about 7 and 4, respectively).

In Experiment 2 of Hogaboam and Perfetti (1978) two groups of fourth graders, skilled and less skilled, were provided with training on two-syllable nonword CVCVCs which were exposed 15 to 18 times. Their response latencies to these were at a similar level to those of high-frequency words immediately after the training. On retest 10 weeks after the original post-test, the same pattern of responses was found.

The nonwords used in this experiment with 4th Graders were also used with 3rd Graders (Experiment 3), who (using similar criteria) had also been split into a skilled and a less skilled group. The skilled group had only required 3 exposures to attain the same response latency to the nonwords as to high-frequency words, and the less skilled had required 6.

Given that the fourth graders had had a further year of reading experience, it could be expected that their reading levels would be higher than the 3rd graders, and probably they would have attained high-frequency response latencies over a similar number of exposures or perhaps slightly fewer. The 4th graders received 15 to 18 exposures for these words. This amounts to 12 to 15 trials more than the skilled 3rd graders needed to reach the response latency of high-frequency words (i.e. three required in Experiment 3) and 9 to 12 trials more for the less skilled 3rd graders (i.e. six required).

This level of exposure, which seems likely to have been considerably more than the minimum necessary for unitisation speed, may have been necessary to obtain the durability of retention in Hogaboam and Perfetti's Experiment 2 with fourth graders. The robustness of learning stands in stark contrast to its fragility in orthographic learning experiments where minimal exposures were provided. This would seem to argue for considerably more than the bare minimum if the target is long-term recall, and raises doubts about quoting Reitsma's (1983) results as demonstrating possible 'spongelike acquisition' of sight words in children learning to read English (Adams 1990) when these are assumed to be retained for sustained periods of time.

2.6.16 Overview of research on repetitions needed for short-term learning of words to levels where they can be recognized rapidly and reliably

Initially, doubts were raised on the relevance of rapid orthographic learning in Dutch to children learning English. Then, from the orthographic learning studies analysed earlier, the following conclusions were drawn:

1. Retention of orthographic detail of words after only a few repetitions occurs in English at a relatively early stage.
2. Younger children needed more repetitions.
3. In slightly older children some effects were seen with just one exposure.
4. Learning increased with more repetitions.
5. Because none of the studies had tested learning beyond a delay of 7 days, there was no evidence on long-term retention.

Training studies, which were not from the orthographic learning paradigm, confirmed that relatively few repetitions were needed by American children from third grade and above, with words and nonwords being learnt by skilled readers with as few as three exposures, with less skilled readers requiring 6 to 7 exposures.

There was also some evidence of skilled kindergartners and first graders learning simple CVC words in as few as four repetitions. There was evidence of increased learning with more repetitions. Training studies provided some evidence on the learning of more complex words not available from orthographic learning studies, as the latter were generally restricted to CVCs.

Studies with young English reception children attempting to learn long words which they were unlikely to be able to decode demonstrated few words learnt despite extensive repetitions, except for one group who could segment both initial and final phonemes and learnt the 10 words presented.

Older American children from fifth and sixth grades learnt complex regular and exception words in as few as six to seven exposures in print, although all words were presented orally multiple times in addition.

There were two training studies which provided evidence on long-term retention: five-year-old English children showed a loss of some learnt words after a month, but American fourth graders showed retention of effects after 10 weeks. As has been discussed in the text, the American study provided substantially more than the minimum exposures likely to be needed to learn the words, and such high numbers of repetitions may well be needed for the results obtained.

2.6.17 Regularity and decodability

In this analysis 'decodable' is used to describe stimuli for which the children could be expected to generate pronunciations independently, and 'non-decodable' those where this was not the case, either because the children were too young to have acquired the necessary skills or, in the case of older children, because the words were very complex.

The term 'decodable' can also be used to indicate words whose pronunciations can be deduced accurately from spellings using the most frequent/regular grapheme-phoneme correspondences, with other words being described as 'non-decodable'. To avoid confusion within the dissertation these are referred to as regular and irregular words. Only two studies reported here contrasted regular and irregular words (Stuart et al 2000 study 1, Manis 1985) and in neither case was any regularity effect found. Manis, however, stated irregular words were pronounced more slowly and less accurately than regular words.

There were only three studies reported in the critical literature review where words can be described as non-decodable in the sense of being hard to decode by the participants. In Stuart et al (2000) the children were 5-year-olds in their reception year and words were selected which were relatively complex, in a deliberate attempt to force learning by sight. Dixon et al (2002), again with reception children, used regular two-syllable concrete nouns which they selected as unlikely to be decodable by the children. The third study, Manis (1985), used fifth and sixth graders.

The two studies of five-year-old reception children found few words were learnt despite more than 30 repetitions, except for a group who could segment both initial and final phonemes. These children learnt 10 concrete nouns after 24 exposures on flash cards when tested for immediate recall.

In the study of older children by Manis (1985), some of the irregular words used were low-frequency, and the majority were not known by the subjects. This effectively meant that those which were irregular words were likely to be non-decodable, as the subjects would not have been able to use grapheme-phoneme correspondences to generate the correct pronunciations of unknown words. The study also included some low-frequency high-complexity regular words, and these could also be considered hard to decode. The participants, who were between 10 and 12 years old, required around six to seven repetitions to learn irregular and high-complexity regular words to unitisation level, compared to only three or four repetitions needed for low-complexity regular words (Manis 1985). These children, however, also received an unstated number of oral presentations prior to the visual presentation of the words, and this may well have reduced the number of print exposures required for unitisation. Hence, even after several years' reading experience, there is the possibility that such words require relatively high levels of exposure for learning.

These studies with widely disparate age ranges were the only ones located for the critical literature review which assessed exposures required for hard to decode or non-decodable words, and there is thus limited information on the number of repetitions required for words children could not decode. This factor is therefore investigated later in this dissertation.

All other studies used words or nonwords with grapheme-phoneme correspondences which children were likely to know, and hence were likely to be decodable by the children. Although Hogaboam and Perfetti (1978) failed to provide examples of their nonwords, they were described as easily pronounceable, and it has been assumed that they were similarly ‘decodable’ by the subjects in their experiments.

For these studies the youngest, least skilled group were a mixture of 6-year-old kindergartners and 1st graders who learned 12 real word CVCs after seven repetitions, despite the words containing illegal or unusual initial or final double consonant letters (Wright and Ehri 2007). These children could not read nonword CVCs. A similar-aged more able group who could read them required only four repetitions, including two error-free trials.

Although real words were learnt rapidly by 6- and 7-year-olds in Wright and Ehri’s (2007) and Cunningham’s (2006) research, studies seem to indicate it was harder for children at a similar level of reading experience to learn nonword CVCs to error-free levels (Ehri and Wilce 1983). The experimental task seemed fairly difficult, which may have adversely affected the learning rate. Here children of around seven required 18 exposures of a nonword to obtain a 91% success rate. This may be considered the level likely to be necessary for children to learn words not initially in their oral vocabulary.

For older children, evidence for rapid learning of decodable nonwords was seen in Hogaboam and Perfetti (1978, Experiment 3). Skilled 3rd graders, normal age range 8 to 9 years, required only three exposures to attain unitisation of easily pronounceable two-syllable nonword CVCVCs, and a less skilled group obtained this with six exposures. With similar sets of decodable words, long-term retention was obtained with 4th graders after 15 to 18 repetitions, and it has been argued that the high number of repetitions may well have been a factor in the robustness of the learning. Certainly the evidence provided by Lemoine et al (1993) described in the next section seems to add weight to this suggestion.

2.6.18 Limitations of the research used for evaluating repetitions required for learning words

All but one of the research studies which have been described aimed to teach words so that they were recognised by sight. In the case of the orthographic learning studies, evidence of recall of orthographic detail was taken as demonstrating that the children had relevant entries in their mental lexicons, and such representations were considered evidence that the children could recognise the words by sight. The remaining studies, which targeted sight word learning, used speed of response or other factors to reach a similar conclusion. Such sight recognition carries with it an assumption of durability of learning: "Sight words are established quickly in memory and are lasting" (Ehri 2005 p.136).

This was one of the primary reasons for selecting 'sight word teaching' studies for the critical literature review. The dissertation research focused on long-term retention of vocabulary and, as memory of sight words is assumed to be ‘lasting’, the studies were relevant as background information. Unfortunately, most of the research reported suffered the disadvantage of assessing retention of learning for very short periods of one or a few days, so long-term learning was not assessed. Only two studies had post-tests which extended beyond this, one for a month and another for 10 weeks.

In addition, the studies often aimed at evaluating the minimum number of repetitions for words to be learnt. This particular aspect was investigated by Lemoine et al (1993), who assessed levels of retention associated with the minimal number of repetitions to obtain maximum accuracy and speed of a sample of words, compared to levels of retention for words where further exposures, referred to as ‘overlearning trials’, were provided after the asymptote had been attained (Experiment 1).

Two groups of 20 3rd graders, poor readers and good readers, received varying numbers of exposures for either 50 regular words or 50 irregular words. The sample of words was subdivided into 10's, with ‘minimally exposed’ having 5 presentations, and ‘maximum exposed’ having 25, with samples between having 10, 15 and 20. Records of response time and accuracy were kept for each trial. Words used were selected randomly from the Carroll, Davies and Richman (1971) norms, and were at Grade 3 reading level. Lists provided in the paper showed that these were one- and two-syllable words of varying frequency and difficulty (e.g. regular – *bag, bought, bounce*; irregular – *said, done, daughter, cough*).

It was likely that many of the words were already known to the children. This was particularly true of good readers, whose accuracy levels for regular words even from the first trial were very high, at 94%, and attained 99% by trial 4. For irregular words the same group started at 86% and attained 96% by trial 3. For poor readers, regular words started at 77% and attained 96% by trial 4, with irregular words starting at 50% and attaining 93% by trial 7.

Speed of response also moved up to asymptote very rapidly. Good readers named regular and irregular words equally quickly, and a significant repetition effect shown in an ANOVA was obtained after 3 to 4 trials, with a speed increase (= latency decrease) of 100ms. For the poor readers, there was a significant difference between regular and irregular word response time, both hitting asymptote around trial 7, with a decrease in response times of around 500ms.

The effects of training were tested for retention with a post-test, one week after completion. Retention of the naming time gain improved with more overlearning trials, particularly for poor readers. For good readers there was only a small difference in naming times (66ms) between words receiving the least training (5 trials) and the most (25 trials) but, given that the gain in training was only 100ms, this still amounts to a substantial relative difference. For poor readers, though, the least trained words had a 240ms difference from those exposed the full 25 times.

Accuracy for good readers, as reported, had started very high and showed minimal changes between least and most exposed words, but there was a clear shift for poor readers. Words trained to an asymptote of around 98% attained accuracy rates on post-test of 80% for 5 repetitions in training, 90% for 10 repetitions, 93% for 15 repetitions and 98% for both 20 and 25 repetitions. The authors commented: "If training had been stopped when naming times reached asymptotic levels of performance there would have been poor retention of the trained skill" (Lemoine et al 1993 p.308). This was based on a fairly short-term assessment of retention of only one week, and one might predict that a longer interval between training and post-test would have led to even poorer retention of training.

Thus the minimal training used in the majority of studies reported, coupled with post-tests after very short intervals, means that, despite the words or nonwords being learnt to sight recognition levels, durability of learning cannot be presumed. Nor can one generalise from minimal repetitions needed for an experimental effect to discussion of normal learning of sight words during school instruction without some caution.

2.7. Summary and conclusions: phonemic awareness and repetition

Research on reading over the last 40 years, although recognising the wide range of factors which affect its development, has centred on phonological awareness, and in particular phonemic awareness, as the core skill in word recognition and decoding ability. Phonemic awareness and letter-sound knowledge are considered critical co-requisites in reading acquisition. These two factors allow an individual, after repeated exposure to words and initial guidance on grapheme-phoneme correspondences, to develop a vocabulary of words recognised by sight, and knowledge of relationships between sublexical orthographic patterns and sound, such that pronunciation of regular words not experienced in print can be achieved, and some approximation made for exception words.

Research studies have shown that, not only does knowledge of grapheme-phoneme correspondences help children learn words with fewer repetitions, but also that to some extent skill at phonemic segmentation predicts aspects of decoding skills. Children’s decoding ability is also related to repetitions required for learning words. In all studies reviewed, children in the higher ability groups required fewer repetitions to learn words than those with lower levels of skill.

A survey of studies of orthographic learning, whose results are often cited in the literature as providing evidence of repetitions required for sight word learning, although demonstrating rapid learning of aspects of orthography, left many questions unanswered regarding its durability, and consequently its relevance to long-term retention and recall.

From training studies, the position is somewhat similar, with clear evidence of rapid learning of CVCs in young children, and of more complex regular words and nonwords in older children, but durability of learning in relation to exposure received has only been tested with 5-year-olds in their first term of schooling and with 4th graders after 15 to 18 repetitions.

There was only a single study which compared repetitions for learning words which varied in ease of decodability for the children (Manis 1985), and two studies which directly looked at the influence of repetitions of words in reading books on learning (both in Stuart et al 2000). It was the meagre number of studies located concerned with level of repetition needed to learn words encountered in books which motivated undertaking the research described in the dissertation.

2.8. The findings of the review studies and research questions 1 and 2

Research question 1 asks whether words encountered in books by five- and six-year-olds require very few repetitions to be recognised reliably. The studies with most similarities to the dissertation research were those of Stuart et al (2000), which used books to teach a mixture of regular and irregular words to English children a year younger than those used for the dissertation. This demonstrated emphatically that even after a large number of repetitions very few words were learnt. The additional year of reading instruction of participants in the dissertation research should, however, mean that they had higher levels of skill than Stuart et al’s participants, and therefore might require fewer repetitions.

The orthographic learning study for American children in their first year of instruction showed only a 50% retention of words encountered after six repetitions, and this was for regular words only, suggesting that more repetitions would be required for the dissertation, where the sample of words contains both regular and irregular words.

The training study for American children in their first year is the only one where few repetitions were required, but this was for regular CVC words taught by flashcards. Both these factors make it likely that fewer repetitions will be required than for the dissertation subjects, where the words assessed cover a range of structures taught through books.

Overall the prediction is that the dissertation participants are likely to require considerably more than a few repetitions to learn to recognise words reliably.

2.9. Word class and morphological complexity: background research

The background information for research questions 3 and 4, which focus respectively on word class and morphological aspects of reading, is described in the sections which follow. The studies located for these topics do not evaluate repetitions required to learn contrasting categories of words, but provide information on speed and accuracy of learning. This can only provide guidance of words likely to be harder to learn, and hence is suggestive of which category may require more repetitions.

2.9.1 Word class

Research question 3 asks whether content words require fewer repetitions to learn than function words. A brief description of relevant research is provided below.

2.9.1.1 Contrasting properties of function and content words

Linguists distinguish between content or open-class words, and function or closed-class words. Content words include nouns, verbs and adjectives, and have new members coined regularly. Function words, which are mostly short, include determiners, pronouns, conjunctions and prepositions, which express or represent grammatical relations between content words and form relatively closed classes, with new function words rarely introduced to a language. The core distinction, though, which is felt to be in part responsible for different processing in reading, is that content words are the primary meaning-carriers, with function words acting as syntactic markers, defining relationships between the actions and entities described by the content words, often having relatively little meaning in themselves (Davelaar and Besner 1988, Schmauder et al 2000).

There are also variations in length and frequency between content and function words, both important factors in word recognition, particularly in young children. Function words tend to be short, and many appear at very high frequencies in text. In the children's printed word database which is based on reading materials from 5- to 9-year-olds (Masterson et al 2010), of the 100 most frequent words in the text, which accounted for almost 52% of all tokens, 89 were function words.

Shorter and higher-frequency words tend to be recognised more easily by children (Lemoine et al 1993, Moseley 2004).

2.9.1.2 Differences in word-class recognition in children

For children, there is evidence of function words proving harder to learn than content words. Stuart et al (2000), in a study of English beginning readers, found fewer function words than content words were recognised in a post-test where both had received the same number of exposures in teaching sessions. Bruskin and Blank (2004), working with third and fifth graders, found that function words were recognised more slowly and less accurately than content words. Function words were sufficiently troublesome for some children to learn in a study carried out by Aaron et al (1999) that teachers described them as ‘demon words’. Seymour et al (2003) obtained a lower recognition accuracy rate on function words than content words in English for a sample of Scottish children of average age 6.56 years. It must be said, however, that out of 14 groups included in this cross-linguistic study, covering 12 languages, only the Portuguese obtained a similar result with higher accuracy on content words, with the remaining 12 groups showing similar rates of accuracy on both word classes, or a slight advantage for function words. The results of the Scottish children, though, are in line with the small amount of other research on English-speaking children.

2.9.1.3 Word-class effects in young readers

The study by Aaron et al (1999) was one of the few which looked across a range of age levels in children (as well as college students). This seemed relevant to the research carried out for the dissertation, and consequently will be reported in some detail here.

Children from grades 2 to 6 and a sample of college undergraduates read a list of 40 monosyllabic content words taken from the highest frequency set for grades 2 and above in the Word Frequency Book (Carroll et al 1971). They also read 40 letters in list form, and 40 function words matched in frequency and length with the content words, also presented in a list. All lists had 20 items repeated twice. The list started with the 20 different words or letters, with the second set repeated in a different order. Note was taken of accuracy and speed of response.

Function word lists were always read more slowly than content word lists, all differences being highly significant, except among college undergraduates where the difference only approached significance (p=0.06). The lists of content words were read at the same speed or faster than the letters, from grade 3 onwards. Only 2nd grade children read letters significantly faster than words. Aaron et al treated words being read as fast as individual letters as evidence that they had been unitised and were read by sight, hence by grade 3 in the study content words were presumed to be part of the children's sight vocabulary. This did not occur for function words for any age-group studied; even the University undergraduates read them more slowly than letters.

The function words were matched for frequency and length with the content words, which to an extent removes some of the advantages accruing to many function words, which are both shorter and more frequent than content words. With these parameters controlled, it would appear that function words required longer to process than content words. The error count provided evidence that function words were harder to recognise, with all age groups making fewer errors on content words.

2.9.2 Possible explanations for word class differences

2.9.2.1 Imageability

As raised early on in this discussion, in general function words are felt to lack semantic content in comparison to content words, with Ehri (1977 p.700), for instance, referring to them as ‘relatively meaningless functors’. A reflection of semantic content is imageability: words which have ‘high imageability’ evoke sensory imagery easily, having concrete referents, and are considered to have more ‘meaning’ for individuals than relatively abstract words with low levels of imageability.

The imageability dimension is reflected in the Stroop-like task used by Ehri (1977), where third and sixth graders were required to name pictures whilst ignoring words printed on them. The higher the imageability of the word, the more the child’s naming speed for the pictures was slowed by interference. Speed of naming 20 pictures with content words printed on them was significantly slower than those showing function words.

Using a similar approach with adults, Davelaar and Besner (1988) demonstrated that the word-class distinction between function and content words disappeared completely when words printed on the pictures were matched for imageability, raising the possibility that it is imageability rather than word class per se that is responsible for many research findings showing word-class differences where imageability had not been controlled (Allport and Funnell 1981, Janssen et al 2010). Thus the Ehri et al finding with children reported above cannot be taken as reliable.

2.9.2.2 Other language parameters

Function words appear later than content words in normal language development (Brown 1973), and seem to be prone to more disruption when children have specific language disorders or delayed language (Curtiss 1977). Bruskin and Blank (2004) found that less skilled readers show a greater differential between function and content words than do skilled readers on word recognition and spelling. It could be that poorer-reading children rely more heavily on semantic support in word recognition, if their slow reading progress is due to deficits in decoding skills, in which case content words would have an advantage, generally having higher imageability ratings.

It is also possible that less skilled readers include a proportion of children whose problems in wider language functioning contribute to literacy problems, as suggested by Snowling (2008), and their difficulties with function words are similar to those found in children with disorders or delay in oral language. Certainly it may be the less skilled readers who find function words particularly troublesome – ‘demon words’, as Aaron et al (1999) described them.

2.9.3 Summary: word class and reading

It is clear from Aaron et al’s (1999) study that, with frequency and length controlled, function words are harder to recognise than content words. Other parameters than word class, though, seem to contribute to this difference. Imageability plays a part in accuracy and speed of recognition in normal reading, and in studies where this was controlled, the word class difference disappeared (Schmauder et al 2000, Davelaar and Besner 1988, Janssen et al 2010).

There remain parameters relating to words' linguistic characteristics, including developmental trajectories, where function words differ from content words, and this may well be at the root of differential responses of children with language difficulties.

The fact remains that, in normal reading, parameters such as high frequency, short length and predictability may counterbalance the lack of semantic content and imageability and possible additional linguistic factors associated with function words, making the relative difficulty of their recognition compared to content words not entirely predictable.

2.10. Morphological awareness and the reading of multi-morphemic words

Research question 4 involves a comparison of children's accuracy in reading mono- versus multi-morphemic words. The remaining sections of the critical literature review provide some background.

2.10.1 Introduction

Morphemes are the smallest units of meaning in a language and comprise simple freestanding words (e.g. *hard, ball*) and affixes (e.g. *un-, -ing*). These are combined in different ways to produce additional vocabulary. Other new words can also be created by combining words to make compound words (e.g. *football*). Mono-morphemic words are free-standing words with no affixes, and multi-morphemic words comprise words with affixes (e.g. *unclean, singing*) and compound words.

Much early reading research, particularly on children, concentrated on mono-morphemic words. However, there has been a gradual increase in work on recognition of complex words, primarily on adults, which begins to reflect their importance in reading English, given their high level of occurrence, where, although typical words are often viewed as being simple, i.e. mono-morphemic, they only constitute 26% of the tokens in the CELEX lemma database, the remaining 74% being words of two morphemes and above (Libben 2006). Work on complex words has also shifted the focus for some reading researchers working with children from a focus on phonology to include morphological aspects of reading:

> "Theories of what is involved in learning to read English must take into account that the English language is morphophonemic. The spelling system is based on both representations of sounds (phonemes) and units of meaning (morphemes)." (Carlisle and Stone 2005 p.428)

Research findings over the past three to four decades have demonstrated that, in addition to the critical importance of phonological awareness in learning to read, morphological aspects of English are a significant factor in the acquisition of reading skills and have powerful effects on the processing of words in both adults and children (Bowers et al 2010, Carlisle 2010, Goodwin and Ahn 2010, Singson et al 2000, Verhoeven and Carlisle 2006, Verhoeven and Perfetti 2011).

It must be said, however, that much of the direct work on word recognition has been with children several years older than those involved in the dissertation research. Carlisle and Stone, quoted above, are in fact the only researchers who have worked with younger readers and carried out a comparison of their reading accuracy for mono- and multi-morphemic words, and whose results are therefore directly relevant to the research question.

There have, however, been some findings on the factors which facilitate recognition of multi-morphemic words in adults and, although this may be tangential to the research question, it fills out the picture of possible influences on word recognition for young beginning readers. Key findings from adults will be described, with somewhat more detail on those for children, regardless of their age. Facts about the development of children's knowledge of morphological aspects of reading will make it clear that the limited decoding skills of the five- and six-year-olds may well prevent facilitation of word recognition derived from the morphological structure of multi-morphemic words.

2.10.2 Early research on morphological aspects of children's reading

By the early 1990s, there was clear evidence that morphology affected children's reading acquisition. Several studies had demonstrated that children's knowledge of morphological rules correlated with reading ability (Brittain 1970, Mahony 1994). However, some researchers felt its role in learning to read was not well understood: "How children learn to recognise more complex words on the basis of their constituent parts remains to be established" (Verhoeven and Perfetti 2003 p.211). A good deal of more recent research has attempted to deal with this aspect by delineating how morphological awareness skills in young readers influence their reading of complex words (Carlisle 2000, Carlisle and Katz 2006, Carlisle and Stone 2005).

The remainder of this review will describe the point in their reading career when most young readers begin to encounter a high proportion of multi-morphemic words in print, the evidence that morphological knowledge contributes to reading skill, and such information as has been collected on factors influencing the reading of multi-morphemic words.

2.10.3 Establishing the link with reading skills

Evidence has accumulated which demonstrates a clear relationship between the level of skill demonstrated on morphological awareness tests, such as the famous 'This is a wug. Here are two …?' test developed by Berko (1958), and reading ability (Bowers et al 2010, Carlisle 2010, Goodwin and Ahn 2010, Singson et al 2000, Verhoeven and Carlisle 2006, Verhoeven and Perfetti 2011).

The research strategy followed the sequence of an initial phase where, using correlational studies, a relationship was established between morphological awareness and level of reading ability, with a causal relationship being demonstrated later with intervention studies, where training to improve morphological awareness also raised levels of reading skills, very much paralleling the research on phonological awareness.

A very early study comparing children's morphological awareness with reading using a revision of the Berko test was carried out on first and second graders by Brittain (1970). Scores on the test correlated significantly with reading ability assessed on the primary reading profiles at 0.01% level for first graders and 0.001% level for second graders, after controlling for intelligence. Later studies establishing the relationship of morphological awareness with reading and spelling have controlled for other factors known to contribute to reading progress.

Morphological awareness has been shown to contribute unique variance to the reading skills of beginning readers from first to third grade after taking phonemic or phonological awareness into account (Apel and Lawrence 2011, Carlisle and Nomanbhoy 1993, Kirby et al 2012, Wolter et al 2009), as well as various other skills (e.g. orthographic knowledge, verbal and non-verbal ability).

2.10.4 Intervention studies on morphological awareness skills and reading

There have been sufficient studies on such interventions for two meta-analyses to have been carried out evaluating experimental effects. Goodwin and Ahn (2010) looked at 17 independent studies of children with literacy difficulties, and Bowers et al (2010) carried out a systematic review of 22 studies including some with readers of average ability. Although there were some studies in common, overall they considered more than 30 separate studies covering children from preschool to adolescents.

Instruction targeting morphological skills not only produced significant improvements in their use, but also resulted in significant increases in word identification, speed of word reading, reading comprehension and spelling. Effect sizes were small to moderate, Bowers et al quoting levels of d=0.41 for reading tasks and d=0.49 for spelling outcomes. Goodwin and Ahn obtained slightly lower figures for children with literacy difficulties, with reading showing d=0.24 and spelling d=0.20.

Similar positive results have been described in reviews taking an integrative narrative approach. Reed (2008) covered seven studies ranging from kindergarten to 12th grade, and obtained positive effects on both reading and spelling, as did Carlisle (2010), who evaluated 16 studies. There is thus by now sufficient evidence to consider a causal connection between morphological interventions and reading and spelling skills highly probable.

2.10.5 Morphological knowledge and beginning readers

The shift to an extensive acquisition of multi-morphemic words in speech (Anglin et al 1993) and in reading vocabulary seems to occur in the middle school years, Nagy and Anderson (1984) estimating that 60% of new words encountered around this time are derived forms. These changes are reflected in the relative importance of phonology and morphology in children's reading skills. Thus, although research studies with first graders have demonstrated contributions of morphological awareness after controlling for phonological awareness, such contributions tend to be small, with the major contribution coming from phonological awareness (Carlisle and Nomanbhoy 1993). The balance gradually shifts with increasing age and knowledge of complex words, research studies showing an increasing contribution from morphological awareness. Singson et al (2000) reported just such an effect, with phonological awareness providing no significant contribution above grade 3 in their study of third to fifth graders.

As Carlisle (2000 p.173) pointed out, "younger readers are likely... to be still learning basic strategies for sounding out polysyllabic words", and even this would only apply to children with several months' experience of learning the more common gpc's. The evidence of a clear contribution from morphological awareness in first grade, some of which has been cited earlier, is sufficiently convincing that one might revise strong statements that morphological awareness instruction is most appropriate for "later grades of schooling when the students' knowledge of frequent spelling patterns has been thoroughly established and automated" (Adams 1990 p.156). It is true, however, that the high contribution of phonological awareness early on suggests that it is of primary importance.

The utility of early inclusion of morphological instruction is to some extent supported by research which has demonstrated that some children with literacy difficulties showed larger improvements to reading and other skills with morphological intervention than children with normal skills in reading (Bowers et al 2010, Reed 2008). This led Bowers et al (2010 p.170), compilers of one meta-analysis, to comment: "Making written morphology structures more salient could scaffold more effective use of phonological knowledge for less able readers."

There is no logical reason why such tuition could not begin to be implemented at an early stage, complementing phonological decoding, and perhaps facilitating access for some children. In fact, it should be borne in mind that the modest contribution of morphological awareness compared to phonological awareness in the early years could partly reflect emphases in the curriculum.

2.10.6 The development of the morphophonemic bases of word recognition

"Students who are learning to read derived words are likely to make use of morphemes that are transparent in sound and spelling..." (Carlisle and Stone 2005 p.432). Such words add a suffix without any change to the pronunciation or orthography of the stem (e.g. *singer* and *windy)* and, as the quotation above states, are among the earliest to be recognised and pronounced accurately. The clear relationship between the stem and its derived form seems to facilitate children's ability to take advantage of aspects of the morphological system which are firmly established in their speech.

Carlisle and Stone demonstrated that elementary students from second and third grade read two-syllable derived (i.e. multi-morphemic) words which retained the pronunciation of the stem, 'transparent in sound and spelling', as described above, faster and more accurately than two-syllable mono-morphemic words matched for frequency, word length in letters, and final elements of spelling (e.g. *windy* v. *candy*).

So, although it is true that English-speaking first and second graders have restricted meta-linguistic knowledge of derivational endings, showing ability to productively apply only a few high-frequency affixes to word and nonword stems (Duncan et al 2009b), derived words with high-frequency affixes such as agentive and instrumental –er, adjectival -y, diminutive -y, and adverbial -ly, at least in transparent derivations, are facilitated by such morphemic structure for word recognition fairly early on in young readers, and to some extent the same is true of spelling (Bryant and Nunes 2008, Kemp 2006, Nunes et al 1997).

2.10.7 Self-teaching and morphological rules

Logically, in order to move from reading words with simple transparent links to those with less overt relationships, children must have learnt not only additional affixes but the shifts in pronunciation and meaning associated with them. It is assumed that, over the early years of reading, through multiple encounters with affixes across a range of words, they may infer for themselves the complem-entary set of rules related to morphology, particularly as the relationships may be facilitated by clearer links in orthography than in speech (e.g. *nature, natural; severe, severity; precise, precision*):

> "Given that in many cases spelling rules are not directly governed by the phonological syllable structure, the learner must convert sounds to an underlying spelling representation reflecting morphemes." (Verhoeven and Perfetti 2011 p.460)

This shift is seen as an essential 'mandatory' step on the way to becoming a proficient reader:

> "There is reason to believe that an increasing attention to relationships between orthography and meaning is mandatory for the efficient reading of derivationally complex words." (Verhoeven and Perfetti 2011 p.460)

In this way the original self-teaching system, envisaged by Share (1995) and demonstrated by Stuart et al (1999a), whereby children independently extend their knowledge of phonological decoding rules, gradually encompasses a further self-teaching system (Verhoeven and Perfetti 2011) which abstracts the rules linked to morphology and culminates in a proficient reader who responds to the morphophonemic structure of English orthography. The early phase in which children focus on transparent derivations can be seen as the first step in engaging with the system in which relationships between families of words with common semantic content derived from the same stem have links in their orthography and phonology.

2.10.8 Frequency effects

2.10.8.1 Introduction

This section sets out to provide descriptions of morphological effects on reading. The general pattern of morphological influences likely to be relevant to the words assessed in the dissertation research is sketched out, together with evidence of whether similar effects have been identified in young readers.

2.10.8.2 Key findings of frequency effects in word recognition of multi-morphemic words

In adults, the frequency with which an individual word is exposed (its surface frequency) affects the speed and/or accuracy with which it is recognised. Multi-morphemic words such as *happiness* are also influenced by the size of the morphemic family with which they share the same base (e.g. *happy, unhappiness*). This is a type count of the different words, not their frequency (Schreuder and Baayen 1995), but the frequency with which the stem or base of multi-morphemic words appears in texts does have a facilitation effect on their recognition (e.g. the frequency of *happy* in texts) (Taft 1979). This is generally only true of words with low surface frequency.

Similar facilitation has been demonstrated by children in US grades 2-3 and 5-6 (Carlisle and Stone 2005, study 1), and in Canada for children from grades 4, 6 and 8 (Deacon et al 2011a).

2.10.8.3 The development of sensitivity to morphological structure in low-frequency derived words

Deacon et al's results demonstrated clear effects of base frequency on complex words with low surface frequency as early as grade 4. This added to some earlier evidence of sensitivity to morphological structure found by Carlisle and Katz (2006), whose results indicated that morphemic family size and surface and base word frequency all accounted for significant variance in the reading of derived words by children in grades four and six.

Carlisle and Stone (2005) found significant effects for younger children from grades two and three who read high-frequency derived words (e.g. *windy*) significantly faster than matched mono-morphemic words (e.g. *candy*), but failed to obtain a significant contribution for the base frequency of derived words for the same children in that study. High- and low-frequency derived words were compared, with number of syllables and base frequency entered into a regression equation. Only number of syllables contributed significantly. For the older children from grades five and six, both number of syllables and base frequency gave significant contributions to word reading accuracy.

There seems to be the possibility here of some parallels with the development of phonological recoding as reflected in the regularity effect. In proficient readers it is only low-frequency words on which regularity effects can be seen. In children this is seen once some basic competence in decoding is present, which is relatively early in second and third grade (Backman et al 1984). Younger readers or older poor readers may not have learnt sufficient gpc's for the effect to be evident (Stuart et al 2000, Stuart et al 1999b).

The same may well be the case with morphological effects, with children who have limited knowledge of affixes not showing any contribution of base or stem frequency effects in reading low-frequency words until the fifth or sixth grade, even though, as described above, some words' morphological structure can help younger children read them more accurately than similar mono-morphemic words. The morphological influences shown at second grade are, though, confined to high-frequency words and suffixes (Carlisle and Stone 2005, study 1).

2.10.8.4 Low-frequency complex words and recognition in young readers

In addition to children's limited experience with affixes used in complex words, many of the words themselves, particularly in studies which make use of low-frequency items, are likely to be unfamiliar not just in print, but in children's experience in oral language, a factor which could impede any possible benefit from morphological structure.

For instance, in Carlisle and Stone's (2005) study, the sample of low-frequency derived words where young children showed no contribution from morphological effects included *queendom, equalize, dramatize*, etc.; hence the authors' comment that the lack of use of morphology was "perhaps because of their inexperience in reading long and unfamiliar words" (Carlisle and Stone 2005 p.439) rings true, particularly as the authors had reported that even the shorter high-frequency words were not read easily, *shady* and *lady* being read correctly only 31% of the time by their second graders.

In the same study there was a high correlation (r=0.73) between children's word-reading skills (Woodcock-Johnson psycho-educational battery word identification subtest) and their reading of the low-frequency derived words. The clear evidence of a link between general word-reading skills and recognition of the low-frequency derived words simply underlines the point that length of words and their unfamiliarity are likely to restrict any benefits from morphological analysis of less frequent derived words until children are capable of decoding the words in question relatively easily, and, although the impact of morphological structure is earlier than envisaged by Adams (1990), so far second graders are the earliest where evidence seems convincing that some advantage has been found, but this was based on phonologically transparent, short, high-frequency derived words.

Morphological awareness has been shown, however, to make an independent contribution to reading as early as 1st grade (Apel and Lawrence 2011). This, one might suspect, applies to affixes learnt in preschool years (e.g. plural and possessive -*s, -ed, -ing*, etc.).

2.10.9 Multi-morphemic words: findings on factors related to recognition

The sample of multi-morphemic words used in the dissertation research included a mixture of different types, which are defined and discussed in the sections which follow. A full list of the words divided into relevant subcategories can be found in chapter 4: Method.

2.10.9.1 General effects: findings which relate to the overall sample of multi-morphemic words

Multi-morphemic words with large morphological families, or whose base or stem appears at high frequency, are responded to faster and more accurately than those from small families or with low frequencies (Feldman and Basnight-Brown 2008, Verhoeven and Carlisle 2006). In compound words the frequency of both lexemes individually can play a part in recognition accuracy (Juhasz 2008). The facilitation that the morphological structure brings to the recognition process is sufficient that all multi-morphemic words are recognized faster and/or more accurately than mono-morphemic words matched in frequency, length in letter and number of syllables (Carlisle and Stone 2005, Fiorentino and Poeppel 2007).

The findings on compound words relate to adults. Similar research has not yet been carried out with children and, although it is relevant background material, it should be emphasised that the younger children from grade 2 included in the Carlisle and Stone research showed limited effects of benefits from morphological structure.

2.10.9.2 Inflected and derived words

Affixes in English belong to two distinct categories: inflectional affixes (e.g. those in *books, singing, walked*) which do not change the grammatical word class of the stem, and derivational affixes, which often change the syntactic class and meaning of the base word (e.g. base word *hope*, derivations *hopelessly*, *hopeful*). These categories “differ considerably with respect to their syntactic and semantic functions, and linguists have traditionally treated these formations as distinct lexical categories” (Raveh and Rueckl 2000 p.103).

Inflectional affixes comprise a closed set of forms used for modulating meanings of base words, without generally changing their syntactic class, and where the shift in meaning is consistent and relatively transparent (e.g. *card, cards; push, pushed*). Compared to many other European languages, modern English is notably deficient in inflectional affixes, having just eight, all of which are suffixes e.g. *-ing, -ed*, plural -(e)s. etc.

Derivational affixes participate in the formation of new words, often changing their syntactic class, but the words to which they can be applied are not predictable, and they can change the meaning of the base morpheme in idiosyncratic ways (e.g. *terrify, terrific; fantasy, fantastic*).

Inflected words are felt to have stronger semantic relations with their stems because their semantic and syntactic relationships are far more consistent (Crepaldi et al 2010).

2.10.9.3 Inflected words

Unfortunately no research on frequency effects or comparisons between recognition of mono- and multi-morphemic words has been carried out on inflected words with children. Work with adults shows clear benefits of high base frequency in their recognition, and that many stems (mono-morphemic words) are recognised more rapidly and accurately than their inflected forms (Baayen et al 1997, New et al 2004, Serena and Jongman 1997).

With evidence of facilitation of recognition in children limited to affixed derived words, one can only speculate that similar effects may occur for inflected words. There is, however, fairly compelling evidence that this might be the case. The majority of suffixes used in inflected forms are present in oral language very early on (Brown 1973), and can be used productively on unfamiliar words in kindergarten and Grade 1 (Berko 1958, Brittain 1970). The clear evidence of knowledge of rules underlying the morphology of inflected words seems highly likely to have effects on printed word recognition, particularly as its contribution to children's spelling has already been demonstrated (Bryant and Nunes 2008, Nunes et al 1997, Pacton and Deacon 2008).

In contrast with the range of inflections known early on, only a few derived endings can be used productively at the same age (Duncan et al 2009b), and as these few are known to facilitate word recognition in comparison to matched mono-morphemic words in grade 2 children (Carlisle and Stone 2005), there is a strong likelihood that inflected words would show similar effects.

2.10.9.4 Non-concatenated inflected words

Although the discussion of multi-morphemic words so far has been on words where morphemic elements are clearly identifiable, the sample of multi-morphemic inflected words used in this dissertation includes several irregular verbs without clear suffixes. These are included as they are also considered multi-morphemic from a linguistic viewpoint (Bauer 1983, Katamba 1993). However, such words, “although expressing the same underlying combination of semantic and syntactic information cannot ...straightforwardly be decomposed” into morphemic elements (Marslen-Wilson 2007 p.177). The difference in irregular words has aroused considerable discussion on whether they are processed in reading in a similar way to their regular counterparts (Marslen-Wilson 2007, Pinker and Ullman 2002).

In adults, irregular forms, though, are known to prime their stem forms (Meunier and Marslen-Wilson 2004, Pastizzo and Feldman 2002) with effects comparable to regular forms. Fruchter et al (2013) carried out some work, also with adults, on irregular verbs, comparing them with regular verbs using priming techniques alongside recordings of brain activity. They obtained similar priming effects for both types of word, and the brain activity information suggested that irregular verbs were decomposed in a similar manner to regular verbs.

The combination of linguistic theory and empirical evidence seemed to justify the classification of this subcategory of words as multi-morphemic for the analysis. This was extended to irregular present tenses and pronouns other than subject forms, all considered multi-morphemic from a linguistic point of view.

2.10.9.5 Derived and compound words

Compound words were referred to earlier, and it was pointed out that, although similar factors are said to apply to their recognition as to other complex words, research findings are based purely on adults. Research on children has been exclusively with derived words and, although similar frequency effects have been found which contribute to recognition accuracy, the youngest group was from grade 4, and therefore considerably older than those in the dissertation research.

2.10.9.6 Contracted forms

Finally we come to contracted forms, where the two morphemes represent a pronoun and a verb (e.g. *it's, she's, he's*) or a verb and the negative contraction (e.g. *can't, won't*). This was an area where very little research could be located, either for morphological effects or for word recognition, either for adults or for children.

The limited studies which were found for children, rather than looking at reading, focused on spelling (Bryant and Nunes 2008, Stuart et al 2004), with particular reference to the use of apostrophes. Even young children notice their existence without explicit teaching. In Stuart et al's study, Year 2 children included them 18% of the time for contracted <'s> and 26% for the <n't> negative form, although not always correctly located.

This, however, is of little help in assessing likely impact on reading recognition. The apostrophe must be considered to add some complexity and hence make contracted forms harder to learn than matched items without an apostrophe. The words themselves are also subject to both orthographic and phonological shifts from their base morphemes, and such transformations are known to create difficulties for word recognition in younger readers (Carlisle and Stone 2005, Deacon et al 2011a, Mackay 1978, Mahony et al 2000). Hence it would seem likely that such multi-morphemic words would be harder for children to learn than matched mono-morphemic words.

2.10.10 Summary and some final comments on effects of morphemic complexity

Overall the facilitation effects derived from base and stem frequency and family size give multi-morphemic words a clear advantage over matched mono-morphemic words, and, if this were the only factor to be considered, multi-morphemic words would be recognised more accurately than mono-morphemic words. There are, however, some factors improving the recognition of mono-morphemic words. Baayen et al (2006) found some morphological effects for these. There is thus facilitation for both mono- and multi-morphemic words, although possibly not at the same level.

In addition, again providing a benefit to mono-morphemic words, evidence from adults shows that they can recognise the stems of many inflected words (mono-morphemic) faster and more accurately than their inflected forms (multi-morphemic).

Contracted forms have been included in the sample of multi-morphemic words used in the comparison made for the relevant research question. Contracted forms, as has been discussed, may well be more difficult for children than mono-morphemic words, a further complication.

There are thus some types of mono-morphemic words which are recognised more accurately, and some which have been shown to be recognised less accurately. All in all, the evidence does not lead to a clear-cut prediction for the samples of words used in the research

In addition, for the five- and six-year-olds in the dissertation research, limited decoding skills may well have had some impact. Carlisle and Stone (2005) reported that the grade 2 children in their study had decoding difficulties with relatively simple high-frequency derived words, and read both *lady* and *shady* correctly only 31% of the time. Such limitations in word recognition are likely to apply to the children in the dissertation research, who were more than a year younger and had received a year's less reading instruction. The limitation was also evident in their performance on decoding tests, where the majority of these children failed to read words with vowel digraphs correctly, and could not read nonwords of two syllables. Such constraints could well disrupt any advantages offered by morphological structure, making it even more difficult to predict the likely outcome of a comparison between mono- and multi-morphemic words.

2.11. Final overview

The main purpose of the dissertation research was to investigate whether the widely accepted notion that children need to see words very few times to learn them, with four repetitions typically being mentioned, was valid for children learning to read from books. Research in the critical literature review, although demonstrating that young American children could learn words with few repetitions, was far from convincing that such learning was durable, and young English children required a considerable number of repetitions to learn words.

In relation to research question 2, words children can decode easily have been shown to require fewer repetitions then hard to decode words, and, in relation to word class effects raised in research question 3, content words have proved easier to learn than function words.

For research question 4, the evidence on the likely outcome of the comparison between mono- and multi-morphemic words suffered from two problems: the bulk of the research was based on adults, and hence not relevant to 5- and 6-year-olds, and even for adults the effects of morphological structure did not provide a simple answer. Sometimes there were advantages for multi-morphemic words and sometimes the reverse, hence there was no clear guidance on the possible result of the comparison.

Chapter 3 Investigative rationale

3.1. Overview

This chapter describes, and sets out to justify, the approach adopted to investigate the relationship between the level of exposure of words in books and their reliable recognition by children in the early stages of learning to read. The study made use of a quasi-experimental design and a quantitative approach. This chapter includes a statement of my positionality.

3.2. Positionality statement

This positionality statement has been drawn up in recognition of the fact that clarification of my views, which stem from my background, professional training, etc. – where I am coming from – helps make transparent to the reader the basis for the approach taken to the investigation. It is useful self-knowledge both in relation to my professional practice as an educational psychologist, and my role as researcher:

> "I think it is important for all researchers to spend some time thinking about... fundamental assumptions they hold (and how this) might influence their research related thinking." (Sikes 2004 p.19)

The statements made below relate specifically to the topic of research (i.e. children's word recognition) and would be different if the investigation had related to social relations, attitudes, etc., where I feel other approaches would be more appropriate.

3.2.1 *Ontology – my view on the nature of reality*

I consider there to be an objective and independent reality capable of being measured. This is a post-positivistic, realistic stance with no assumption of value-free measurement, and reflects the view quoted by Cohen et al (2011), based on Popper (1968), that our knowledge of the world is conjectural, falsifiable, challengeable, changing. “There is no unquestionable foundation for science, no ‘facts’ that are beyond dispute” (Robson 2011 p.31).

3.2.2 *Epistemology – knowledge and how it is constructed*

This I consider subjective, coming through direct experience, discussion with others, and evidence and opinion collected through reading, the latter having a central role in the selection of the topic of investigation and the approach taken to its design. Reading the literature is itself driven by personal views on what is relevant, and how the evidence matches up with your own position, as well as some evaluation of authors’ motivations and the robustness of the findings (Clough and Nutbrown 2012).

My own approach to countering a predisposition to select only such articles as provide supportive evidence of my own worldview was to attempt to include writers taking a very different stance, making clear where their evidence was in conflict with others, so that doubts are transparent to the reader. It must be said that many articles on ‘reading’ take extreme positions, at the same level as religious fervour, and presentation of a balanced account on some key aspects of theory requires constant self-monitoring.

My own key tenet, no matter how persuasive the writing, is whether there is evidence justifying the position, which has been systematically collected and has controls in place to maintain objectivity as far as possible, be these qualitative or quantitative.

3.2.3 *Axiology – Impact on values in research*

The research was carried out in schools with the cooperation of teaching staff, parents and, most importantly, the children. My values here very much stem from initial training as an educational psychologist, and a substantial period working in that role in schools.

3.2.4 *My attitude to children, and its influence on the design of the investigation*

“There is also the question of whether it is ethical to ask people to do things that they normally wouldn’t do, and which may be detrimental to them” (Sikes 2004 p.28). I am very committed to the above view, and feel that children should not be involved in activities during school time which are not in some way beneficial to their development. They should not feel uncomfortable or stressed by the tasks or the interaction with myself.

The research involved children being assessed, mainly on reading materials. ‘Testing’ always raises concerns in education, as it can easily provoke unease, particularly in five- and six-year-olds such as those who participated in the investigation.

To reduce this to minimal levels, children were seen at a time when they normally read to an adult at the school, either a teaching assistant or a parent helper. They were seen in the staff room where other adults were working with children, and where they had spent some time working in the past.

The sessions for the research lasted about 10 to 15 minutes, and always began with reading from their current reading book, which was their normal practice. I would then administer tests which were part of the research. Children were seen over a series of consecutive days. Early tests were deliberately very easy, e.g. providing sounds of letters of the alphabet, and only moved onto tests of individual words (the hardest test) after they had been working with me for over a week. Nerves disappeared very quickly, and feedback suggested that the ‘special treatment’ was enjoyable. A Hawthorne effect, if it occurred, would simply have optimised their performance and not invalidated the results.

The negative effect of such a design was that working on reading only in the limited time slot allocated by the school, and ensuring that the child did not miss their normal reading practice, combined to reduce the number of children it was feasible to assess.

3.2.5 *My status as expert adviser and the teaching staff*

Although the research was an evaluation of teaching materials in the main (i.e. the level of repetition of words in published schemes associated with reliable recognition), teachers obviously could still construe it, in some way, as an evaluation of the effectiveness of the teaching practice in the school. This could well have affected the selection of children deemed suitable to be seen by me. However, a fairly large number were seen initially, and the final selection of participants was based on my own criteria, which excluded some very advanced readers whose skill level and outside reading would have invalidated the investigation.

In most respects, though, this was outsider research, with the focus on materials, and hence many of the reasons why reflecting on positionality, tacit assumptions, and likely effects of pre-existing social relationships is considered particularly important in insider research were not relevant.

3.2.6 *Parents*

As is usual, parental consent was obtained for all children seen, and the parents of those assessed for the project were interviewed and activities discussed. Again this is standard practice for all educational psychologists. In Derbyshire, children are not discussed or seen without informed consent from the parent.

3.2.7 *Other ethical considerations*

Equally in line with the normal procedures for the Local Authority, and the educational psychology service, the permission of the headteacher of the school was obtained for the methods used for assessing the children and for the use of the data collected as the basis of a thesis. Similar approval was obtained from the parents of children who participated in the study.

In general, the ethical requirements of both the British Psychological Society and the Association of Educational Psychologists were followed, as much from personal choice as from official requirements of the university department.

3.2.8 *Methodology*

The research design selected was driven by the principal research question. As Robson (2011) states in the opening stages of his volume on real-world research, “a mantra of this book is that the research question provides the key to most things.” The content of the research questions, though, comes from a personal preference to investigate aspects of learning which are based on behavioural evidence (e.g. children reading) where the skill in question is demonstrated, so in the end the use of quantitative methods, which seemed ideal, clearly stemmed from attitudes I hold.

Quantitative methods deal with numerical data, in my case word recognition accuracy, level of repetition of words, etc. The answers to all the research questions were numerical, and hence the study lent itself to the use of statistical analysis, which is the norm in this approach to research.

3.3. Summary of impact of personal views

In summary, the way the background research was approached, evaluated and presented, although partly defined by scientific methodology, university and Local Authority requirements, was also affected by personal views, as were the details of the procedures used to collect the data for the research and the approach to the data analysis. In addition, although not discussed above, the research questions, besides leading to a reliance on behavioural evidence, were intended to provide information useful for designing instructional material, and it was therefore based on real-world data of children's exposure to their school's reading scheme, another personal preference, namely 'Produce something of practical use'.

3.4. Other comments on the investigative rationale

3.4.1 Repetitions of words needed for learning in the real world: the problem of generalisability of findings

As it was the intention to provide results which were likely to be of practical use, and as relevant as feasible to normal teaching practice, it was decided to use children's exposure to words in books used for teaching them to read. This was to avoid a problem with many research studies, namely that their findings relate to very short-term intervention, and assessment immediately or after just a few days' delay. This was true of the majority of the studies included in the critical literature review, with only two which had substantially delayed post-tests, i.e. Hogaboam and Perfetti (1978) and Stuart et al (2000).

In addition, the teaching approach in the studies often used flash cards or other means only (nowadays) occasionally used for teaching reading, and some of these have been shown to be more effective than learning from books (Stuart et al 2000).

For this reason the level of repetition of words used in the investigation was based on the children's book reading at school. This was accepted as a crude measure, being subject to variation in teaching approaches, given several adults were involved, and the children were possibly distracted from learning by ongoing events both at school and at home. It is, however, subject to the very influences which would affect a large number of children who learn to read in this way, and hence offers the maximum generalisability from a necessarily limited sample.

The approach also assesses repetitions needed when vocabulary appears sporadically over extended time periods, which again is true for many pupils. The approach was not entirely innovatory. Martinet et al (2004), in an investigation of spelling, based the choice of words used in the experiment on a careful study of their level of exposure in books the children encountered. Stuart et al (1999a, b) selected digraphs to be incorporated in nonwords used for word recognition based on the children's actual exposure to those graphemes, in the books they had covered in the school's reading scheme. The real-world data used by these researchers suffered from similar unknown contaminating variables to those used in the dissertation study, but to an extent the inaccuracy in the studies in question was made less critical by using extreme examples. That is, both sets of researchers made use of high, contrasted with very low, exposure levels for the stimuli used for their experiments. It was thus likely that, even if the real exposure values were different, there would still be a considerable difference between the two.

The dissertation study increased the risk of distortions in the data by making use of a wide range of exposure levels, which varied very gradually. These might be inaccurate for some words and, with the measures being close to each other in value, relationships between words in the dataset could be far more easily distorted. In the event, both the ANOVA analyses and the logistic regression showed a highly significant relationship between word recognition accuracy and the level of repetitions, which demonstrated that there was no serious distortion.

Even with all these problems in using real-world data, it was still felt that the gain in authenticity offset the imperfections of the data

3.4.2 An ex post facto quasi-experimental research design

Robson (2011) describes a single-group post-test-only design with no random allocation of participants to different groups as quasi-experimental. This describes the approach taken in this study. Children were selected from a single class group, and chosen so that they were at different points in the school's reading scheme, so as to provide a range of different levels of exposure to the same words. In using pre-existing data derived from school records, the study was not a true experimental design as the 'treatment', i.e. the level of repetition of words, was already fixed, depending on the books each child had read, which had been selected by the class teacher, and hence was not under experimental control; thus this was an *ex post facto* design.

The independent or predictor variable, 'exposure', suffered from the weaknesses associated with this type of research outlined in the last section. Conditions prevalent when the children saw the words were unknown, and no doubt varied on each occasion, the data thus being subject to possible contaminating variables.

This type of design, by reason of such imperfections in the data, is seen as an early phase in the normal development of theory, when rough patterns are observed which “are useful as sources of hypotheses to be tested by more conventional experimental means at a later date” (Cohen et al 2011 p.308). This was not the way the study was conceived. It was considered as a feedback loop from the normal setting to corroborate (or not) findings which derive from well-controlled but artificial experiments.

In this way the research, although imprecise, was not a preliminary phase in discerning a relationship in a relatively immature research field, which would require further refinement by carefully controlled experiments. It was in fact the reverse, a revisiting of real-world data to consider the applicability of well-controlled and widely-quoted experimental findings to the normal setting, a post-positivistic seeking of evidence to re-evaluate claims from existing research.

The inaccuracies were not simply in the unknown quality of presentation of words to the children, but in the fact that, from the outset, it was known that the level of exposure in children's reading books might not be the sole exposure of the words the children had received. Hence the presumed relationship of increasing word recognition accuracy with more repetitions, which is to some extent taken for granted in any training study where children are provided with learning trials to improve their overall accuracy in recognition of a group of words (Dixon et al 2002, Ehri and Wilce 1983, 1987, Stuart et al 2000), could not be taken for granted. However, as mentioned previously, it proved to be adequate for the research, with both the ANOVA analyses and logistic regression producing highly significant results for exposure in relation to word recognition scores.

3.4.3 A pilot study and its limitations

The research was carried out in a normal infants school, and the children were only available for a short period each day. There was a fairly extensive range of assessments to be administered, which resulted in only two children being assessed over each two-week period. This limited the number of children seen, and the dataset used for the analysis were therefore based on an extremely small sample. The project is therefore seen as an in-depth pilot study, whose findings, and any conjectures arising from them, are considered tentative, requiring confirmation from a replication with a far larger sample of children.

3.5. Overview of features of the methods used in the research study

Quantitative quasi-experimental *ex post facto* design

Clear refutable research questions

Numerical and statistical treatment of the results

Post-positivistic acceptance of the need for refinement and corroboration of theory and research findings, particularly in view of the ‘small-scale pilot’ nature of the study.

Chapter 4: Method: Research questions and overall design

4.1. Overview

This chapter outlines the research questions and overall design, and provides descriptions of the Year 1 English children who participated and the tests used. The focus of the research was on the relative levels of repetition needed by words with different characteristics, as well as whether conventional wisdom about very few repetitions being needed to learn words appeared to be true for beginning readers.

4.2. Research questions

The first research question included two criteria relating to the level of book exposure and word recognition accuracy which require some explanation.

4.2.1 Research question 1: Are four repetitions of words sufficient for them to be read subsequently to a 78% level of accuracy?

4.2.2 Minimal exposure level for learning vocabulary for long-term retention

The figure of four repetitions in the research question is based on a widely quoted level of exposure expected to be sufficient for learning sight vocabulary which is based on the results of Reitsma's seminal study: "According to Reitsma's (1983) study, four practice trials may be sufficient for readers to retain information about sight words in memory" (Ehri 1999 p.94).

As reported in the critical literature review, researchers other than Ehri have made similar comments, to the extent that Reitsma's finding that, in a training study of Dutch children, words read four times were subsequently read significantly faster than pseudohomophones seems to have become translated into an accepted truth that, with very limited exposure, words will be learnt for long-term recall and be recognised rapidly and accurately, even by children learning to read English.

It was the suggestion of reliable long-term recall after minimal exposure that it was intended to investigate in the dissertation research, rather than other presumed characteristics of sight words, such as possible recognition by direct visual access without reliance on phonological processing, which Ehri's comment above might suggest. It was not feasible with the research design to differentiate sight reading, 'direct visual access without phonological processing', from recognition with a phonological decoding component. The results obtained were intended primarily for practical purposes, with implications for instructional design. It was hoped they might provide some basis for deciding on minimal levels of repetition in books used for teaching vocabulary intended for long-term retention.

4.2.3 Accuracy of reading familiar words in English

The figure of 78% cited in research question 1 is an estimate of accuracy of reading familiar words by UK children in their second year of instruction. Its basis is described below.

In most languages, familiar words are expected to be recognised rapidly and accurately. English, though, has a deep orthography which is notoriously inconsistent, and beginning readers have low levels of accuracy. In Seymour et al's (2003) cross-linguistic study, after a year of instruction Scottish children attained only 33.89% accuracy on a mix of very familiar function and content words. This compared to 95.44% attained by Dutch children for a similar mix of words after one year's instruction.

The Scottish children, however, were over a year younger (mean age of children: Dutch 6.97 years, Scottish 5.59 years) and, as discussed in the critical literature review, immaturity seems to be an important factor in the slow development of word recognition skills among children learning to read in the UK, who start around the age of five years.

Even an older group of Scottish children in the Seymour et al study (mean age 6.56 years), with a further year of reading experience, only obtained an accuracy rate of 76.39% for very familiar words, a level still well below the Dutch sample. It should also be pointed out that the older Scottish children were not below-average readers, and indeed were reading very well for their age, obtaining a mean reading age of 7.22 years on the word reading subtest of the British Ability Scales (Elliott 1996).

Children used in the dissertation research reported here, like this Scottish sample, were in their second year of reading instruction, and reading above their age level, hence it was decided to use the level of accuracy of the older Scottish children as the criterion for words which have been learnt to a level of recognition equivalent to familiar words.

The ratio of function to content words in the Seymour et al vocabulary (18:18) which produced the combined 76.39% accuracy rate for the older Scottish children was different from that used in the vocabulary used for the dissertation research (51:130). As separate figures were available for function and content words in the Seymour et al paper, it was feasible to adjust the accuracy rate to be in line with the proportions used for the dissertation research. This resulted in a 77.56% accuracy rate which has been rounded to 78% for use in later analysis, and is shown in research question 1. The calculation and brief comments can be found in appendix 1.

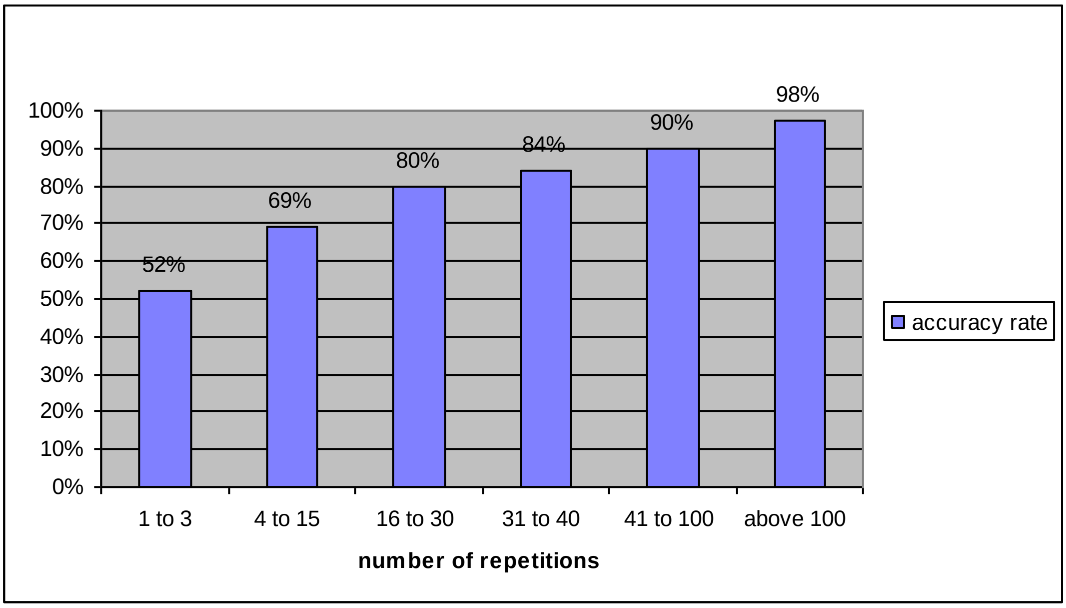
Taken overall, the use of a criterion based on accuracy levels to be expected for very familiar words seems reasonably close to a child variant of the use of recognition accuracy of high-frequency words used in research with adults. The assumption that a 78% level of accuracy might be expected after a very low level of repetitions in books read provided a stringent test of what has become an accepted truth about the ease of acquiring words for long-term retention.

4.2.4 Applying the criterion of 78% to decide on the level of repetition in books associated with reliable recognition

The 78% rate of accuracy will be applied to samples of words in different frequency bands to assess what level of repetition is associated with a success rate similar to that found by Seymour et al (2003) for very familiar words, as illustrated in Figure 4.1. The lower bands have been kept fairly narrow to differentiate between words with different characteristics which may require different levels of repetition to attain reliable recognition.

The first two bands are those directly related to research question 1. If the results of young English children learning to read are similar to Reitsma's findings with Dutch children, words in the first band (1 to 3) will not have had sufficient repetitions to be recognised reliably, whereas those in the next band (4 to 15) should be so recognised. If more than 15 repetitions proved to be necessary it was hoped that the next two bands would prove to be sufficiently narrow to provide some guidance on approximate levels of recognition required for reliable recognition.

Figure 4.1: Analysis of word recognition accuracy for different levels of repetition



As Figure 4.1 shows, it was not until words had been repeated in books between 16 and 30 times that the criterion was reached for the sample of words analysed. The lowest frequency band in which this was attained is taken as indicating the level of repetition required for reliable recognition, and in Figure 4.1 it is the band from 16 to 30 repetitions.

This is necessarily considered as approximate, given the very small sample of children in the study. It would require a far larger sample to obtain statistically viable results. Norming samples used for psychometric tests typically use more than 100 children for a given age band. The dissertation research, however, was essentially exploratory, where it was felt that if the results of a small sample of average children contradicted a widely-cited view that children learn words with very few exposures, then reporting this might suggest the need for a further larger-scale study, in view of the possible severe limitations on generalisation based on so few children.

4.2.5 Refining the principal research question – additional related questions

The relationship between children's decoding skills and the level of exposure required for attaining a level of accuracy in recognising very familiar words was explored in research question 2, with the impact of word characteristics such as word class and whether the word was mono- or multi-morphemic explored in questions 3 and 4.

4.2.6 Research question 2: Is less repetition required for words that are within the children's phonic decoding abilities?

To an extent the answer to this research question could be considered highly predictable, as a comparison of words where children know all the gpc's with those where they do not has parallels with the ubiquitous regularity effect which has been extensively researched (Metsala et al 1998, Seidenberg et al 1984, Stanovich 1991, Waters et al 1984). In the last of these, lower frequency regular words which contain common grapheme-phoneme correspondences were recognised more quickly and accurately than low-frequency words containing elements which are atypical.

In the early stages of learning to read, not all gpc’s have been learnt, and hence even regular words may have elements which children do not know and hence are ‘atypical’. As with irregular words, such words logically will be harder for children to pronounce correctly, and accuracy rates will be lower than on words where all the gpc’s are known.

As explained, the frequency band in which the accuracy rate of 78% was first attained indicates the level of repetitions needed for reliable recognition. This criterion will be met earliest by the most accurate category, probably in a lower frequency band than the category most difficult to recognize, thereby indicating fewer repetitions are required. For this research question the category is predicted to be words within the children’s phonic decoding abilities. Thus the answer to the research question is predicted to be Yes, in line with the ‘regular better than irregular’ results which extensive research has demonstrated.

The purpose of the research question within this study, though, was wider than just assessing relative difficulty for recognition, in that it sought to determine approximate levels of repetition associated with words within and beyond the children’s existing phonic decoding abilities, i.e. the frequency band within which reliable recognition was attained by the two categories.

The theoretical underpinnings to the question derive from the work of Jorm and Share (1983) and subsequent developments formulated by Share (1995, 1999 and 2004). The central tenets of this have been succinctly stated by Share (1995 p.155): “The process of word recognition will depend primarily on the frequency with which a child has been exposed to a particular word, together of course with the nature and success of item identification.”

Successful item identification is seen to be to be dependent on the application of phonic decoding skills. “Exhaustive letter-by-letter decoding (en route to correct pronunciation) is assumed to be critical for the formation of well specified orthographic representations because it draws a child’s attention to the order and identity of the letters” (Share 2004 p.268).

The logic of the two quotations taken together led to the prediction that words which fell within children’s phonic decoding abilities would be correctly pronounced, and this success in item identification would lead to fewer exposures being required for such words to be learnt than for words which contained gpc’s as yet not acquired or atypical. In other words, decodable words would be likely to be learnt after fewer repetitions than those which children could not decode.

Share takes as an essential preliminary the fact that children require phonemic awareness and letter-sound knowledge to develop decoding ability, and these skills were assessed as part of the baseline assessments here. In later writings Share recognised that aspects other than ease of decodability may play a role in children’s speed of learning, particularly whether the word to be learnt is in a child’s oral vocabulary: “The availability of a familiar phonological form may be a significant factor in orthographic learning” (Share 2004 p.290). Evidence of such a relationship was found by Nation and Cocksey (2009), where words recognised in an oral lexical decision task were 2 to 3 times more likely to be read aloud successfully than those not recognised.

The words assessed in the dissertation research had been selected as likely to be in young children’s oral vocabulary. They were selected from words used in books designed to teach children to read, which in general use child-friendly language. It was therefore anticipated that decodability would be the primary factor in word recognition, and not knowledge of the words, as all the vocabulary was likely to be known by the children.

As reported in the critical literature review, other factors such as imageability also affect word recognition, and may well play a part in variation in learning rates for function and content words (this dichotomy is investigated in research question 3). For research question 2, the focus is on relative levels of repetition required for learning a sample of words in relation to their phonic decodability by children, without regard to variation according to other parameters of difficulty.

4.2.7 Establishing children’s phonic decoding abilities

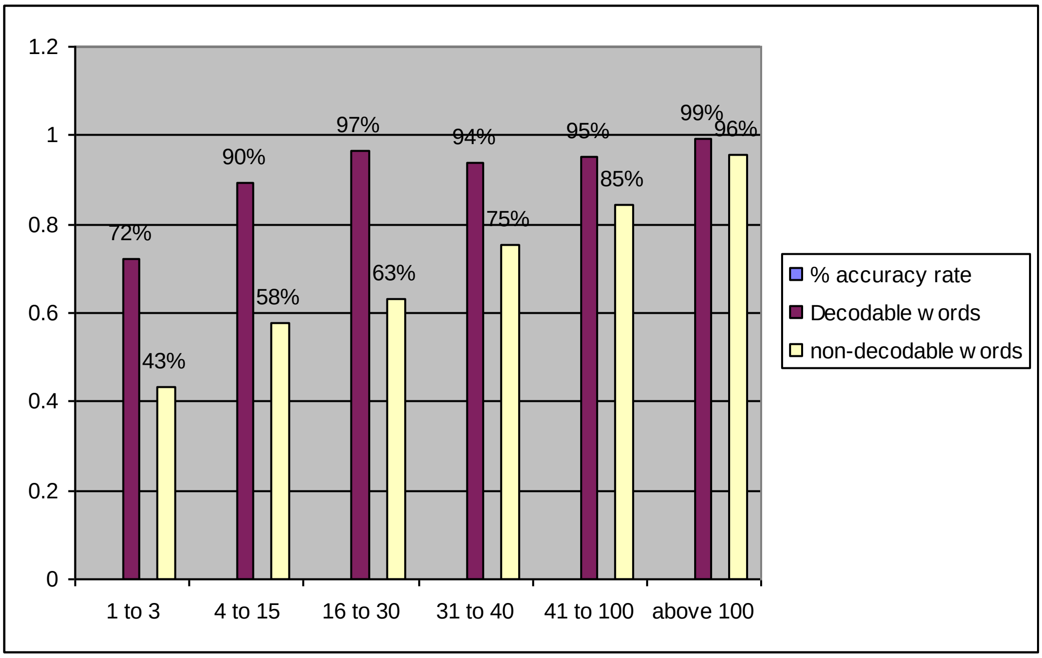
Tests of phonological awareness (segmentation and blending), knowledge of letter sounds, and decoding tests using nonwords and words likely to be unfamiliar in print, were utilised to determine which words would be considered phonically decodable. Brief details of the tests are provided later in this chapter.

A fuller description of their content, together with a discussion of how the results were used to select words which the children were likely to be able to decode and those they were not, is provided in chapter 5.

4.2.8 Comparing levels of repetition needed for learning words within children's decoding ability with those presumed to be beyond their existing level of skill

There is a two-step process to answering the research question. A bar chart will be used to evaluate when a category attains 78% accuracy, and will provide the initial guide to the level of repetitions needed for reliable recognition. If this is different for the two categories, the one attaining this in the lower band will be considered to be the one requiring fewer repetitions. Thus in Figure 4.2, decodable words are considered to require fewer repetitions, meeting this requirement in the band from 4 to 15, whereas non-decodable words attain this in the band from 41 to 100.

Figure 4.2: Accuracy rates of decodable and non-decodable words



The accuracy rates will then be subject to an ANOVA, whose results will be used to answer the research question. This includes a covariate for the length of words in letters, a factor known to have a significant impact on word recognition accuracy in younger readers (Moseley 2004).

The bar chart result will also be used to provide a rough guide to the minimum levels of repetition of words in books needed by Year 1 English children who learn to read from them. As discussed earlier, it is recognised that this figure must be considered as an informed guess. This approach has also been used to compare different word categories in research questions 3 and 4.

4.2.9 Research question 3: Is less repetition required for content than for function words?

There is evidence that both children and adults find function words harder to recognise than content words (Aaron et al 1999, Ehri 1977, Healy 1981, Schindler 1978, Stuart et al 2000). Brief details of this research were reported in the critical literature review in Chapter 2. Most of the studies described related to American children from around the age of 8 and above. The dissertation research will provide evidence of accuracy of recognition of content and function words for younger English children.

4.2.10 Research question 4: is less repetition required for mono-morphemic than for multi-morphemic words?

The focus of reading research has for some time been the importance of phonemic awareness in the development of phonological decoding and its relationship to the acquisition of reading skills. The orthographic structure of words, though, is based not just on phonemes but also on morphemes. It has been shown that young children's morphological awareness ability makes a separate contribution to word reading, once phonological skills have been taken into account (Apel and Lawrence 2011, Leong 2009, Singson et al 2000), but the role of morphemic structure in early word recognition has been subject to little research, with an assumption that use of morphological structure in word recognition is likely to be a relatively late development. Adams (1990), for instance, stated that sensitivity to 'roots or meaning bearing fragments' is a late developing aspect of word reading.

More recent work, though, by Carlisle and Stone (2005) demonstrated that morphemic sensitivity provided a small but significant contribution to word recognition in young American children from second and third grades, with a clear advantage for orthographically and phonologically transparent derived words (e.g. *windy, hilly*) over words matched for frequency and spelling which were not derivational (e.g. *candy, silly*).

Children used for the dissertation research were both younger than Carlisle and Stone's subjects and had had less reading experience, and it was of interest to evaluate whether morphemic structure played some part in their word recognition skill. Research question 4 compares the relative accuracy of mono-morphemic and multi-morphemic words. Research on children's sensitivity to morphological aspects of words was reported in the critical literature review. However, much of the research on morphological effects on word recognition was carried out on adults and older children. This was clearly indicated in the review, and lends some weight to the uniqueness of the results provided by research question 4.

4.2.11 Research question 5: What is the relative influence of repetition, word length in letters, decodability, word class and morphemic complexity on accuracy in word recognition?

This will be investigated by entering the above factors as predictors in a logistic regression.

4.3. Method: Brief background and summary of procedure

The overall design of the research and the assessment materials were trialled in 2006 in a pilot study, and the main research described in the dissertation was carried out in 2007. In 2006 both reception children and Year 1's were assessed; however, there were severe limitations on time available in 2007 and the study therefore focused exclusively on Year 1’s, some of whom had been assessed on pilot tests in the previous year.

In 2007, seven children from a Year 1 class in an English infants school were assessed on text passages containing words from the reading scheme with which they had learned to read. The same words were also tested in a randomised word list a week or so later. The children were also given a reading test and a decoding skills test. Only the results of the word lists have been used for the research reported in this dissertation. Word recognition was treated as correct when the child pronounced the word reasonably promptly and without overt use of word attack skills. This was felt to be in keeping with recognition of familiar words.

4.3.1 Participants

The seven children (three girls and four boys) were aged between five years eight months and six years nine months, and were selected from Year 1 of an English infants school. Children were chosen who had attended the school from the beginning of their school career and had learnt to read through daily reading of books from the school's reading scheme. Children who were reading extensively from other books were excluded from the sample. Confirmation was obtained from the parents that the school's reading books had been virtually the only books read by the children whilst they were learning to read, although they were frequently read to from other books.

The school is located in a small town in Derbyshire which had a mixed catchment drawn from Council estates, private houses, and a new private housing estate near the school.

All the children had shown normal progress in reading at the time of their assessment, and had received between 13 and 21 months of reading instruction, depending on the date of their assessment and the date they entered school.

4.3.2 The school's approach to teaching reading

The children had begun by learning individual sounds for letters of the alphabet in the nursery. The reading scheme for the Reception Year and Year 1, at the time of the study, was a combination of four published schemes (Ginn, Oxford Reading Tree, New Way, and 1, 2, 3 and Away), the books being organised into blocks of similar levels of difficulty. Children progressed through the blocks in an approximately similar order, completing most books in one block before continuing to the next, with teachers having the option to allow them to jump blocks or require them to repeat them, in line with the children's reading attainment. In practice, it was more likely that a child would read supplementary books or have separate intervention than repeat sections. There was often a degree of reluctance from parents (and the children) to agree to teacher requests to read the same books again.

From the reception class onwards, the children read every morning from 9 to 9.30 with the teacher, a teaching assistant or a parent helper. Books read were both recorded on a printed record sheet listing the titles of all the books in the approximate order in which they were to be read, and also entered in the child's home-school book with the exact pages read. Children were expected to read nightly with their parents, who entered relevant page numbers in the home-school book. In addition to the daily reading, there were phonics lessons based on the National Literacy Strategy and some based on the *Jolly Phonics* programme. There were also weekly spelling tests linked to the National Literacy Strategy.

4.3.3 Calculation of individual exposure to words for each child using a database of the reading scheme and children's reading records

The words for each book used in the school's reading scheme were entered on a 'book database' which identified the individual book, summarised the vocabulary it contained, and counted the number of repetitions of each word. This was carried out for the first 400 books in the progression used, which generally covered those read by the end of Year 1. A list of the books organised in the teaching sequence is provided in appendix 2. The school's record of the children's reading was entered on a separate database and linked to the book database.

For the purposes of the assessments of word recognition of reading scheme vocabulary which are described below, viz. the Word List and the Text Test, the children's exposure to words was calculated to the day preceding the day of their assessment. Each child's record showed books in each 'block' read from beginning infant school up to the day preceding the Word List, and included the words read during the Text Test. This calculation of exposure was the basis for the level of repetition for each word used in the analysis. A full list of this vocabulary, showing each child's individual exposure, is provided in appendix 3.

The school was extremely systematic in recording all books read on individual child records which were kept in the classroom in a ring binder. Each child had a record spanning several pages which was kept in a single polythene envelope. A sample of one such record is included in appendix 4. Photocopies were taken of all the records of the children in the study. The photocopied records were checked against each child's home-school book, which gave the title of each book, and the date particular pages were read. They were all in agreement. This provided an independent check on the school records, and was used on occasions to clarify the dates when a book was read.

The use of individualised measures of exposure in research has precedents. Stuart et al (1999a) used such data to evaluate children's frequency of exposure to digraphs. Martinet et al (2004) used a lexical database in their research on spelling accuracy.

4.4. Tests and materials

4.4.1 Word reading

The British Ability Scales Individual Word Reading Subtest was used (Elliott 1996). This is a word-naming test of progressively more difficult words presented on an A4 card. Tables in the test manual provide conversions to reading ages in months and to percentiles.

4.4.2 Knowledge of the alphabet

The children were required to give the sound of each letter in the alphabet. These included <c, x, q>. The ‘hard’ phoneme /k/ was accepted for <c>, and the letter names or an attempt at their pronunciation for <q, x> (e.g. /kw/ and /ks/). Individual letters were presented on cards one at a time, in the groups shown below, although not in any set sequence within a group: <a, i, p ,s, t>, <c, e, h, k, n, r>, <d, g, m, o, u>, <b, f, j, l, w>, <q, v, x, y, z>, followed by the consonant digraphs <ch, sh, th>.

The lower-case letters provided as phonic resources for the Progression in Phonics scheme were used (DfEE 1999, 2004). These were in Sassoon Primary font, 24 point, except for <q>, where a font which showed a small tail was substituted. This had reduced confusion with <p> for the reception children tested during the pilot in 2006. Children received one point for each letter and consonant digraph correctly pronounced.

The alphabet test, although used as a screening instrument with the reception children during the pilot in the previous year, at this level was used to promote confidence in the early stages of the assessment, with all the Year 1s making virtually no errors at all. This assessment, together with that for segmenting and blending and the decoding skills test, were used in the analysis as the basis for deciding which of the words assessed on the word lists were likely to be decodable by the children, and which were unlikely to be decodable, as part of the analysis for research question 2.

4.4.3 Test of language comprehension

(Wechsler Pre-School and Primary Scale III 2004)

The child selects a picture from a choice of four, relying on a single word in the question, e.g. ‘Where’s the roundabout?’ The words tested can be seen in appendix 5. This test was used to ensure that all the children were of at least average ability on language comprehension, and did not form the basis for any analyses. The test allocated one point for each correct response. All the children scored at least at average levels. A scaled score of 10 is average and the children’s scores ranged from 11 to 14.

4.4.4 Test of segmentation

The children were required to provide the initial letter sound of several words, and then segment CVCs, CCVCs and CCVCCs. On the initial letter segmentation and CVC segmentation, the researcher modelled the procedure on one or two words if the child was uncertain. Words were repeated if the child forgot them. Children received one point for each word correctly segmented. The full list of the stimuli used can be found in appendix 6.

4.4.5 Test of blending

The children were required to blend individual sounds spoken by the researcher, the sequences all producing real words ranging from VCs to CCVCCs. The children were provided with feedback and any necessary help to ensure they understood the task. This was limited to VCs and CVCs. Sounds were repeated a second time if a child found it difficult to recall them. The children received one point for each word correctly blended. The full list of stimuli used can be found in appendix 7.

4.4.6 Decoding Skills Test

This test was always administered in the same session as, and directly after, the segmentation and blending tests described above, with the intention of promoting the use of blending skills on unfamiliar words. This test was specially designed for the research. It covered 27 regular one-syllable words with short vowel sounds spelt with one letter, ranging in complexity from CVCs to CCVCCs, and a further 14 words to assess vowel digraphs (viz. <ar>, <a.e>, <ay>, <ea> as in *leak*, <i.e>, <ir>, <oa>, <o.e>, <oi>, <oo> as in *rook*, <ou>, and <ow> as in *clown*).

Words were selected for this test with preference for those that had not appeared at all, or at minimum exposure levels, in the reading scheme. This was not feasible for all words, and for children who were well on in the reading progression approximately 15 of the 41 words tested had been seen before, around 10 at levels of 5 exposures or fewer over their total reading input. Only 2 or 3 words exceeded 9 exposures, but all were CVCs, and the graphemes in these words were also tested in a nonword test to remove any doubt about children's decoding skills. Thus for all seven children most words were unfamiliar, and the proportion of unfamiliar words increased the fewer books they had read. For the younger children typically only three words had been seen before, of which two had an exposure below 5 and one CVC had around 10 exposures.

Only two words (*clap* and *pet*) also appeared in the Word List assessment. A full list is provided below:

CVCs: *jam, pin, nut, pup, sad, hug, pet, sum, vet*

CCVCs: *pram, step, flag, clap, slug, crab, plum, drop, flat*

CVCCs: *lift, mend, mint, pump, camp, desk*

CCVCCs: *trunk, skunk, plank*

Digraphs: *pay, jar, bird, rook, rose, nose, kite, pipe, boil, rake, leak, pound, coach, clown.*

The words were printed in large lower-case letters (36 point Arial) in the centre of an A5 page in landscape format. Once the child attempted the word, the page was turned over to reveal an illustration of it. (A sample of a page of the test stimuli and accompanying picture is included in appendix 8.) Children were given one point for each word correctly pronounced (maximum = 41).

A summary of the results is given in Chapter 5. They formed part of the basis for the split between the words between likely or unlikely to be decodable by the children, used as part of the analysis required for research question 2.

4.4.7 Phonological Assessment Battery (PhAB) Non-Word Subtest (Frederickson et al 1997)

This test consists of 23 nonwords of gradually increasing difficulty from CVCs to 8- and 9-letter two-syllable items. The stimuli include two single-syllable items of 4 and 5 letters containing vowel digraphs (*nabe* and *leaze*), and some of the longer two-syllable items also contain digraphs. Norms for the test start at 6 years. Most of the children only managed the first 11 items, which were single-syllable, with a single vowel letter with a regular short sound. A full list of the words for this test and the children's results can be found in Chapter 5 and, as with the Decoding Skills test, the results were used in splitting the words between decodable and less decodable.

4.4.8 Text Test

This was devised specifically for the research and piloted on a sample of children in 2006, the year prior to the research. It consisted of 15 separate passages to be read aloud, each printed in 18 point Arial font on one or two pages facing a thematic picture. Vocabulary for all but two of the passages related to specific blocks of books in the school's reading scheme, the later ones relating to books read in Year 1.

Content words had been selected from the core vocabulary of the different published schemes used, as these were words which appeared at high numbers of repetitions. This restricted the choice available and made it difficult to control for many of the variables which are known to influence word recognition accuracy, for example imageability (Laing and Hulme 1999, Nilsen and Bourassa 2008), rimes in the words exposed frequently in the reading scheme (Walton et al 2001a and b), etc. Some attempt was made to ensure the words covered a range of different phonic skills covered at several different levels of exposure, and that the words varied in complexity.

The first four passages of the Text Test were designed for reception children assessed during the course of the pilot in 2006. The seven Year 1 children assessed in 2007 all started at passage 5 and continued through the test with words drawn from later stages in the reading scheme, to at least passage 12. Some completed further passages but the Word List (next section) only contained vocabulary from passages 5 to 12, in order that all seven children would be assessed on the same basis. The eight passages between them contained 181 different words, of which 130 were content words and 51 were function words. For the purpose of the research, which set out to investigate levels of exposure necessary for rapid and reliable recognition, only words read correctly without the use of overt word attack were treated as correct, and awarded one point each.

The Text Test was administered over a period of two to three days, with children reading two or three passages on each occasion. Passages 5 to 12, which contained the words used in the Word List, have been provided in appendix 9.

4.4.9 The Word List

All 181 words which appeared in the Text Test were compiled into a single randomised list printed in 18 point Arial font with at most 17 words to the page. A full list of the words can be found in appendix 3, together with the individual level of exposure for each child on each word. Each word appeared once only in the list and, as with the Text Test, scoring was one point for each word correctly pronounced without overt use of word attack skills. The Word List was administered at least a week after administration of the Text Test, to reduce effects of facilitation, administration being spread over two to three days.

4.4.10 Summary of split-half reliability for tests used

Information on the statistical reliability of the tests used is provided in Table 4.1. The coefficients were either extracted from the manuals for published tests, or calculated using Cronbach's alpha for those developed specifically for the research. A reliability value of 0.7 to 0.8 is considered adequate for ability tests (Field 2005).

Table 4.1: Split-half reliability for tests used

Test	Split-half reliability
British Ability Scales – Word Reading Test	0.88 from 5 years to 5 years 11 months 0.95 from 6 years to 6 years 11 months
Test of Language Comprehension WPPSI III	From 0.91 to 0.96 depending on age of child
Alphabet knowledge	0.88
Segmentation Test	0.94
Blending Test	0.86
PhAB	0.95
Decoding Skills Test	0.88
Word List	0.97

4.5. Procedure and timescale of assessment

The tests were given in the following order, with minor variations when children were absent:

1. Alphabet and Language Comprehension
2. Several passages from the Text Test each day until all relevant passages were completed

3. The Segmentation, Blending and Decoding Skills Tests – all given in a single session.
4. British Ability Scales Word Recognition Subtest
5. At least a week after the Text Test, the Word List
6. The non-word test was administered around the same time as the Word List.

The children were assessed during the Spring and Summer Terms of 2007. Following the last tests administered, each child's reading record was photocopied and then double-checked for accuracy against the home-school book.

4.6. Children's level of skills demonstrated on the tests used in the study

The results of the tests used for the analyses detailed in chapter 5 are shown in

Table 4.2.

Table 4.2: Children's gender, and average performance (and s.d.) on the tests administered

Description	Mean (s.d.)
Gender	3F 4M
Age (months)*	74.1 (5.3)
WPPSI language comprehension Scaled score of 10 demonstrates average ability	12.5 (1.4)
BAS reading age (months)	83.7 (4.9)
Alphabet knowledge (max. = 29)	28.3 (1.1)
Segmentation Test (max. = 25)	23.1 (3.2)
Blending Test (max. = 20)	16.7 (3.4)
PhAB (max. = 23)	12.4 (3.9)
Decoding skills (max. = 41)	29.9 (5.3)
Word list (max. = 181)	142.4 (24.9)

*The ages of the children were based on the date the BAS was administered, which was approximately one week after the commencement of the overall assessment.

4.7. Correlations between the tests used in the research

4.7.1 General comment

There were only seven participants, and on several tests there was little variation in scores. In some cases this was due to a ceiling effect (e.g. alphabet knowledge and segmentation), with children scoring at or close to the maximum level afforded by the test. This reduced the possibility of a significant correlation and, as can be seen in Table 4.3, very few correlations were significant.

Table 4.3: Correlations between tests used in the research (Pearson's)

	BAS	WPSSI	alphabet	segment	blend	PhAB	decode	Word list
BAS		-0.168	-0.013	0.176	0.691	0.538	0.918**	0.889**
WPSSI	-0.168		0.413	-0.696	-0.652	-0.440	-0.412	-0.348
Alphabet knowledge	-0.013	0.413		-0.437	-0.496	0.271	-0.329	0.097
segmentation	0.176	-0.696	-0.437		0.793*	0.272	0.433	0.186
blending	0.691	-0.652	-0.496	0.793*		0.382	0.866*	0.658
PhAB	0.538	-0.440	0.271	0.272	0.382		0.541	0.445
Decoding skills	0.918**	-0.412	-0.329	0.433	0.866*	0.541		0.787*
Word list	0.889**	-0.348	0.097	0.186	0.658	0.445	0.787*	

* Correlation is significant at the 0.05 level (two-tailed)
** Correlation is significant at the 0.01 level (two-tailed)

4.7.2 Significant correlations between the tests

The British Ability Scales Word Recognition Subtest (BAS) contained many words which it was unlikely the children could phonically decode. Of the first 30, which were administered to all children, only 13 were entirely composed of gpc's which they had been taught as part of their phonics learning. It was essentially a test of word knowledge. It correlated significantly with the decoding skills test and the word list, both of which involved recognition of real words.

The segmentation test correlated with the blending test as, although there were only minor variations on the segmentation test, the children who obtained less than maximum also scored poorly on blending.

The blending test had a reasonable amount of variation in the scores, and showed a significant correlation with the decoding skills test. Many of the words on the decoding skills test consisted entirely of gpc’s covered in their phonics tuition (27 of 41), and could have been built up using word attack skills based on blending, hence the positive correlation. To some extent this was supported by the results, as children who were the poorest at blending also scored the lowest on the decoding skills test.

Chapter 5 Repetition and word recognition

5.1. Overview

This chapter explores the level of repetition required to establish reliable word recognition in beginning readers, and the extent to which this varies

(1) when children know the grapheme-phoneme correspondences in the word,

(2) when they are dealing with function and content words, and

(3) in relation to mono- and multi-morphemic words.

The relative contribution of these factors to children's word recognition is also evaluated.

Descriptive statistics, i.e. means, standard deviations, etc., are employed to show levels of repetition associated with reliable recognition. ANOVAs are used to evaluate whether differences between words with contrasting characteristics are significant. Finally a logistic regression is used to assess the contribution of these different factors to children's word recognition.

5.2. Descriptive statistics and ANOVA analyses used for research questions 1 to 4

Research questions 1 to 4 make use of a 78% accuracy rate as a criterion for reliable recognition. In the first question this is used to evaluate whether words which have been repeated at least four times in the children's books are recognised reliably. In the next three questions it is used as the first step in deciding which category of words in the comparison for the research question requires fewer repetitions. The next step is to test this with a two-factor ANOVA to answer the research question.

The band in which words first meet the criterion of 78% is considered as an approximate guide to the level of repetition required for reliable recognition and, although not needed to answer the research question, has been reported as pertinent to the level of repetition appropriate to books used for teaching children to read.

5.3. Hypotheses on likely outcomes of the analyses based on existing research

There was no existing research on the level of repetition needed in books for Year 1 children to attain reliable recognition, and this was an exploratory exercise to see whether four repetitions were sufficient, or roughly what level of repetition was required by decodable words, content words, etc. Hence there were no hypotheses based on existing research regarding outcomes relevant to research question 1. The research, however, was undertaken as I believed that young readers would need to see words considerably more often for reliable recognition to be attained.

As regards relative levels of difficulty in learning different types of word, there was some information available on this for research questions 2 and 3, as detailed in the critical literature review, and briefly referred to in chapter 4 and later in this chapter. For instance, for research question 2 it was predicted that words which were within the children’s phonic decoding abilities would be recognised more accurately than those that were not, and it was hypothesised that a significant main effect of decodability would be demonstrated by the ANOVA.

It was also predicted that there was likely to be an interaction between level of exposure and relative accuracy of recognition of the word types in the frequency bands. In the lower bands there are likely to be significant differences in accuracy between word types. This was likely to reduce as the more difficult of the word types approached the level of repetition needed for them to be recognised reliably.

Thus difference in accuracy between contrasting word types was likely to be at a maximum in the lower bands, with this difference gradually reducing to non-significant levels as the second word type attained the level of repetition required for children to recognise them reliably. Once this level was reached for both word types it would be expected that similar levels of accuracy would be shown in high frequency repetition bands.

The analysis which follows is presented in the order of the research questions.

5.4. Research question 1: Are four repetitions of words sufficient for the words to be recognised subsequently to 78% level of accuracy?

In order to answer research question 1 clearly, it is necessary to provide a detailed analysis of accuracy rates not just for words seen exactly four times, but also for words in nearby levels of repetition.

Table 5.1 shows the accuracy rates from 1 to 15 repetitions. The accuracy rate for each level of repetition represents the mean of the accuracy rates for the children calculated individually, and in this way gives equal weighting to the children whose scores are included. This is essential as the number of words at each level for individual children varied according to the selection of reading books they had encountered. A more detailed explanation of the calculation has been provided in appendix 11.

Table 5.1: Accuracy rate for data aggregated at each level of repetitions from 1 to 15

repetitions	accuracy rate	No of words in sample
1	49.4%	91
2	33.7%	38
3	68.5%	28
4	**59.5%**	**28**
5	59.0%	44
6	71.4%	21
7	71.7%	29
8	77.4%	16
9	70.0%	13
10	56.0%	15
11	73.2%	26
12	79.2%	7
13	65.5%	19
14	58.3%	13
15	58.3%	8

As can be seen, not only was the level of accuracy at four repetitions well below the 78% criterion specified in the research question, but this was true of all levels up to and including 11. In fact the rate of 79.2% shown at 12 repetitions is the only exception between 4 and 15 repetitions, and is based on a sample of only seven words. Thus not only was it true that four repetitions were not sufficient for children to attain the 78% accuracy rate but, taking the overall sample of words from 4 to 15 repetitions, it was true for their mean accuracy rate (69.3%), as shown in Table 5.2.

The answer to research question 1 is, therefore, No: four repetitions were not sufficient for words to be recognised at an accuracy level of 78% and, although there were only 28 words in the sample on which that was based, given the fact that there were 239 words in the overall sample for 4 to 15 repetitions which equally did not attain 78% accuracy, it cannot be considered a chance variation.

The accuracy rates for all six bands and overall are shown in Table 5.2, and the bar chart based on it is shown in Figure 5.1. It can be seen that the accuracy rate exceeded the criterion for reliable recognition once words had been encountered more than 15 times.

Table 5.2: Mean accuracy rates and standard deviations for words in each frequency band and overall

Frequency band	1 to 3	4 to 15	16 to 30	31 to 40	41 to 100	Above 100	Total
No. of words in sample	157	239	174	92	247	358	1267
Mean accuracy rate	52.3%	69.3%	80.1%	83.8%	89.8%	97.5%	80.6%
s.d.	34.4%	27.3%	22.0%	27.1%	13.5%	4.3%	26.2%

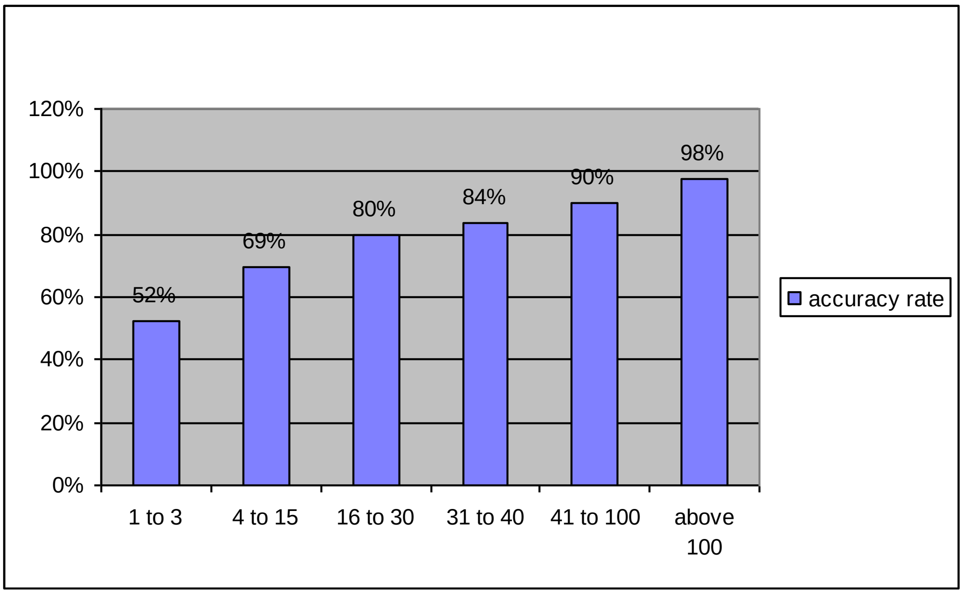
The data were analysed using ANOVA, with word length as a covariate and children as a random factor.[*] The covariate attempted to control for the known significant effect of word length on word recognition in young readers (Moseley 2004).

The main effect of number of repetitions was significant ($F(5, 130) = 7.14$, $p<0.001$), as was the covariate for word length in letters ($F(1,130)=48.76$, $p<0.001$). Planned comparisons were carried out between the frequency band where the criterion was not attained (4 to 15) and the remaining bands, using the Bonferroni adjustment for the five comparisons. This required a 1%

[*] Details of the design of the ANOVA analysis can be found in appendix 12

significance level instead of the normal 5% level, using the formula suggested by Tabachnick and Fidell (2013 p.272), where the 5% level is divided by the number of comparisons.

Figure 5.1: Accuracy rates for the six frequency bands



Only the top three bands were significantly different from the 4 to 15 band, with $p \leq 0.001$, with both adjacent bands (i.e. 1 to 3 and 16 to 30) not being significantly different from the 4 to 15 band. Thus, although there were clear differences in the accuracy rates for the three bands (52%, 69%, and 80%), the differences were not sufficient to obtain significant differences in the statistical tests. The comparison of 1 to 3 v. 4 to 15 had a significance level of p=0.08, and that of 4 to 15 v. 16 to 30 of p=0.02. A level of 0.01 was required for significance after the Bonferroni adjustment, to achieve a familywise alpha rate of 5%.

Hence, although words repeated 4 to 15 times failed to attain the level equating with reliable recognition, the accuracy rate was not statistically differentiated from the words in the 16 to 30 band which did. This undermines any statement that words in the 16 to 30 band were reliably recognised and demonstrates, in line with comments in chapter 4, that the estimate of level of repetition required based on the bar charts is approximate.

It is extremely difficult to show significant differences in an ANOVA based on small groups, even where there are clear differences in the means, particularly where, as in this case, there is variability in the skill levels of individual children, evidenced by the large standard deviations seen in Table 5.2 (Pallant 2013).

5.5. General comment on known underestimate of repetition count used as indication of children's exposure to words

The level of repetition of words in the school's reading scheme books which the children had read formed the basis for the data used in all analyses. This was a known underestimate. All the children saw words in other lessons and outside school, even though care had been taken to select participants for the research whose primary source of reading material, at home as well as at school, was their school books. The count of repetitions used for the research was consequently the minimum level that the children experienced and if, for example, after 30 repetitions measured in this way, children were still exhibiting low accuracy rates, then 30 repetitions or fewer were clearly insufficient for reliable recognition. If it had been feasible to include additional exposure experienced elsewhere it would simply have increased the count, showing that even higher overall exposure had not been enough. The initial finding remains correct, but is overly conservative.

In the current analyses for research questions 1 to 4, the minimum level of repetition for the frequency band associated with reliable recognition is therefore likely to be an underestimate of overall exposure needed as the school's reading books were not the only source of encounters with printed words.

It would still seem to provide some basis for considering book exposure needed for children who, as for this group, were exposed to words elsewhere.

5.6. Research question 2: Is less repetition required for words that are within the children's phonic decoding abilities?

5.6.1 Hypothesis based on existing research findings

The hypothesis was that words which were within the children's decoding abilities would require fewer repetitions than those which were not. As discussed in chapter 4, it was felt that the fact that fewer repetitions were likely to be required for words where children knew all the gpc's than for those where some were unknown was highly predictable, and to some degree similar to the well-known regularity effect.

What was also of interest, however, from the data collected to answer research question 2, was the approximate level of repetition in books associated with reliable recognition for the word types contrasted. Research data for this question are not available for year 1 English children, particularly in relation to words learnt from sporadic exposure in the books used in teaching children to read. It was felt that such information related to an important parameter in the design of instructional material.

5.6.2 Evaluating the phonic decoding skills of the children

As discussed in the critical literature review, there are core skills which research has found to be associated with children's progress in reading skills, for instance phonemic awareness and knowledge of letter sounds, and are now considered as 'critical co-requisites' (Share 1995) which underpin the development of decoding skills.

A collection of baseline tests were used which assessed decoding skills evidenced in reading nonwords and unfamiliar real words, as well as the phonological skills felt to support them. These two sources of data were drawn together in an attempt to provide a firm basis for deciding on the decoding skills known to the majority of children. Segmentation, blending and alphabet knowledge provided evidence of the phonemic awareness skills of the children and the letter sounds known. The PhAB nonword subtest contains a small sample of nonwords, and the results on these demonstrate the use of such skills in word recognition. In addition to this, the decoding skills test, which was based on real words, provided supportive evidence of word recognition skills, but only for some of the items it contained. This is explained in detail in the section preceding its analysis.

5.6.2.1 Segmentation and blending tests

Means and standard deviations for the segmentation and blending tests are shown in Tables 5.3 and 5.4. All words used as stimuli were monosyllables containing a single vowel letter with a short pronunciation. A score of a single point was awarded for each item correct. Full lists can be found in appendices 6 and 7.

Table 5.3: Segmentation: means and standard deviations

Structure	Minimum	Maximum	Mean	Mean as %	Std. Deviation	No. of children successful	% of successful children
Initial sound	6	6	6.0	100.0%	0.00	7/7	100%
cvc	7	7	7.0	100.0%	0.00	7/7	100%
ccvc	2	4	3.7	92.9%	0.76	7/7	100%
cvcc	2	4	3.6	89.3%	0.79	7/7	100%
ccvcc	0	4	2.9	71.4%	2.0	5/7	71%

Table 5.4: Blending: means and standard deviations

Structure	Minimum	Maximum	Mean	Mean as %	Std. Deviation	No. of children successful	% of successful children
vc	2	2	2.00	100.0%	0.00	7/7	100%
cvc	5	6	5.9	97.6%	0.38	7/7	100%
ccvc	2	4	3.4	85.7%	0.79	7/7	100%
cvcc	0	4	2.7	67.9%	1.4	6/7	85%
ccvcc	0	4	2.7	67.9%	1.5	6/7	85%

It can be seen that the majority of children were successful at most of the structures in both tests. These range from CVC to CCVCC structures for segmentation and from VC to CCVCC structures for blending.

Decoding skills evidenced: The majority of the children were aware of phonemes in monosyllabic words whose structure was similar to the items tested, and were capable of both segmentation (which is linked to spelling skills) and blending (which is linked to word attack skills). They would probably show similar competence with subcomponents of items tested (e.g. VCC). Thus children who could blend five sounds and produce CCVCCs such as *spend* and *stink* could well also cope with VCCs they contain, such as *end* and *ink*. This assumption was made when accepting the structure of words considered as decodable.

5.6.2.2 Alphabet knowledge

Of the seven children, four passed all items, two passed all but one letter (confusion between j and i) and one made errors on three letters (j, y and w). None of the errors made on individual letter sounds were made when the children were reading words. The above results produced 100% success rates on 26 of the 29 items. For the three error letters the means and standard deviations were: <j> mean 57%, s.d. 53%; both <w> and <y> mean 86%, s.d. 38%.

Decoding skills evidenced: All single-letter consonant graphemes and single vowel letters with a short pronunciation were considered decodable, as well as three common consonant digraphs.

5.6.2.3 Phonological assessment battery – nonword subtests (Frederickson et al 1997)

The items tested are shown in Table 5.5 with the percentage of children passing each item. The majority of children passed all nonwords containing a single vowel letter whose pronunciation would predictably be short. The two monosyllabic words which contained vowel digraphs (*nabe* and *leaze*) were failed by most children, as were all the words of two syllables.

Table 5.5: Nonwords: Means and standard deviations

nonword	Mean	s.d.
tib	71%	49%
lom	100%	0%
rad	100%	0%
pim	100%	0%
gat	100%	0%
fot	100%	0%
lub	71%	49%
hin	100%	0%
chog	100%	0%
trum	86%	38%
pran	86%	38%
nabe	0%	0%
leaze	14%	38%
haplut	29%	49%
yutmip	14%	38%
musnat	14%	38%
pootfeg	14%	38%
shendom	29%	49%
ligtade	14%	38%
cromgat	29%	49%
ropsatch	29%	49%
rissbick	29%	49%
plutskirl	0%	0%

Decoding skills evidenced: This provided supportive evidence for word recognition of some structures assessed in segmentation and blending, i.e. CVCs and CCVCs and one consonant digraph, <ch>. In addition there was negative evidence for words of two syllables, which were failed by the majority of children, as were both vowel digraphs, <a.e, ea> and the consonant digraph <ze>.

5.6.2.4 The decoding skills test

Words were selected to use in this test which had appeared rarely or not at all in books from the reading scheme which the children had read. Despite this, there was a clear possibility that some words might have been encountered in other reading material both at school and outside. This undermined evidence of decoding skills where there were only one or two words as possible evidence.

Table 5.6 shows summary results of the decoding skills test, with details of the words which contained digraphs where the majority of children passed the item. The full list is given in chapter 4.

Table 5.6: Decoding skills test: means and standard deviations

Max score	structure	Mean	s.d.	Mean as %	Word used
9	cvc	8.6	0.5	95%	
9	ccvc	8.6	0.5	95%	
6	cvcc	5.0	1.8	83%	
3	ccvcc	2.3	0.8	76%	
2	<o.e>	1.3	0.8	64%	rose, nose
1	<ay>	0.7	0.5	71%	pay
1	<ow>	0.6	0.5	57%	clown
1	<ar>	0.4	0.5	43%	
1	<ir>	0.4	0.5	43%	
1	<oo>	0	0	0%	
2	<i.e>	0.3	0.5	14%	
1	<oi>	0	0	0%	
1	<a.e>	0.3	0.5	29%	
1	<ea>	0.1	0.4	14%	
1	<ou>	0	0	0%	
1	<oa>	0.1	0.4	14%	

For the structures already covered in the segmentation and blending tests there were multiple examples (27 items) covering the same structures from CVC to CCVCC, all containing a single vowel letter with a short pronunciation. All were passed by the majority of the children, providing supportive evidence of word recognition and possible decoding of items found in the segmentation and blending tests.

For individual vowel digraphs, however, there were far fewer items, and some words could well have been learnt from encounters outside the reading scheme books. For instance one word passed by the majority of children was *pay,* which can be seen in many shops as part of *Pay here* signs.

It was therefore not clear whether children were decoding the word or had learnt to recognize it. In addition, there were no parallel items in segmentation and blending which contained a long vowel sound. For these reasons successful reading of words containing the vowel digraphs was not considered as reliable evidence of decoding, and such gpc's were not included as part of the children's phonic decoding skills.

It should also be pointed out that, at the date of the commencement of the assessment, no digraphs had been taught as explicit phonics objectives. For all the participating children, these graphemes were not covered until the later stages of Year 1, term three in the National Literacy Strategy.

Decoding skills evidenced: Support for possible decoding of monosyllables containing single vowel letters with a short pronunciation from CVC's to CCVCC's, when considered alongside the segmentation and blending results.

5.6.2.5 The evidence overall, taken together with phonics teaching received: the children's phonic decoding skills

There was evidence that children could segment, blend and recognise words from CVC to CCVCC. Many two-phoneme consonant clusters were assessed, and it was therefore decided to accept clusters not assessed as being decodable, as these had formed part of the explicit phonics teaching in the reception year and Year 1. A similar view was also taken of children's knowledge of doubled consonant letters and the <ck> digraph. A list of the phonics objectives taught to the children up to the time of the research is shown in Table 5.7.

Triple consonant clusters (e.g. <spr>) were not, however, considered as decodable, as none had been assessed in any of the baseline tests. This last decision only resulted in the single word *splash* being placed in words which were considered unlikely to be decoded by the children.

Table 5.7: National Literacy Strategy including Progression in Phonics (2004): the objectives up to Year 1, term 2 taken into account as phonics tuition received by the children

Sounds of initial consonants and short vowel sounds a –z.
Consonant digraphs: sh, ch, th, wh; also qu
Doubled final consonants: ll, ss, ff, zz, as well as ck
Initial consonant clusters: bl, br, cl, cr, dr, dw, fl, fr, gl, gr, pl, pr, sc, sk, sl, sm, sn, sp, st, sw, tr, tw *
Common word-final clusters: ld, nd, lk, nk, ng, lk, sp, ct, ft, lt, nt, pt, st, xt, lf
s for plurals
*N.B. Some triple consonants had been taught but were excluded from the list as they were not included in the baseline tests.

The more common consonant digraphs (<ch, sh, th >) were considered decodable based on successes in the test of alphabet knowledge, and <wh> was also accepted as decodable, as it had been explicitly taught as part of the National Literacy Strategy. Only monosyllables were considered as decodable, based on the failure of the majority of children to decode two-syllable nonwords. The overall pattern of skills demonstrated by the majority of children in the group, on the baseline tests of alphabet knowledge and decoding described in the preceding sections, were used to split the vocabulary in the word list between those considered decodable by the children and those not.

In essence, the baseline tests indicated that, monosyllabic words with a single vowel letter with a short pronunciation were decodable by the majority of the children, and the remainder of the vocabulary was considered as non-decodable. The resultant split of the overall vocabulary tested between decodable and non-decodable words is shown in Table 5.8.

Table 5.8: Words assessed split between decodable and non-decodable

Decodable – single vowel letter with short pronunciation (64)						
a	but	fast	has	Jim	pet	sniff
and	cat	fat	hen	left	pig	stop
at	chicks	fish	hens	lets	pink	swim
back	clap	fox	him	Mum	ran	Ted
bag	cross	fun	in	not	rats	think
Ben	did	get	is	nuts	red	this
Bens	dog	got	it	of	Sam	up
black	duck	grass	its	off	sat	when
bus	dug	had	Jill	on	skip	will
						with
Non-decodable – monosyllabic (73)						
all	cart	guess	lived	ride	the	wont
are	climbed	have	look	roll	there	worked
ball	come	he	mole	said	they	worms
barked	cried	heard	mouse	school	to	would
bike	door	her	my	seat	two	you
birds	feed	here	no	see	was	you’re
blue	find	house	out	she	we	zoo
bread	food	I	paint	some	were	
brown	gave	key	park	splash	what	
cant	go	like	play	straw	white	
car	green	likes	pool	tails	who	
Non-decodable – polysyllabic (44)						
Alex	doing	Granny	lady	rabbits	trouble	
animals	donkey	greedy	lettuces	sandwich	under	
Annie	downhill	Harold	little	something	wanted	
any	everyone	Helen	magic	standing	yellow	
Billy	finding	horses	morning	swimming		
Billys	foxes	hotel	over	Teddy		
children	garden	jelly	parrot	tiger		
couldnt	going	Jennifer	pictures	tortoise		

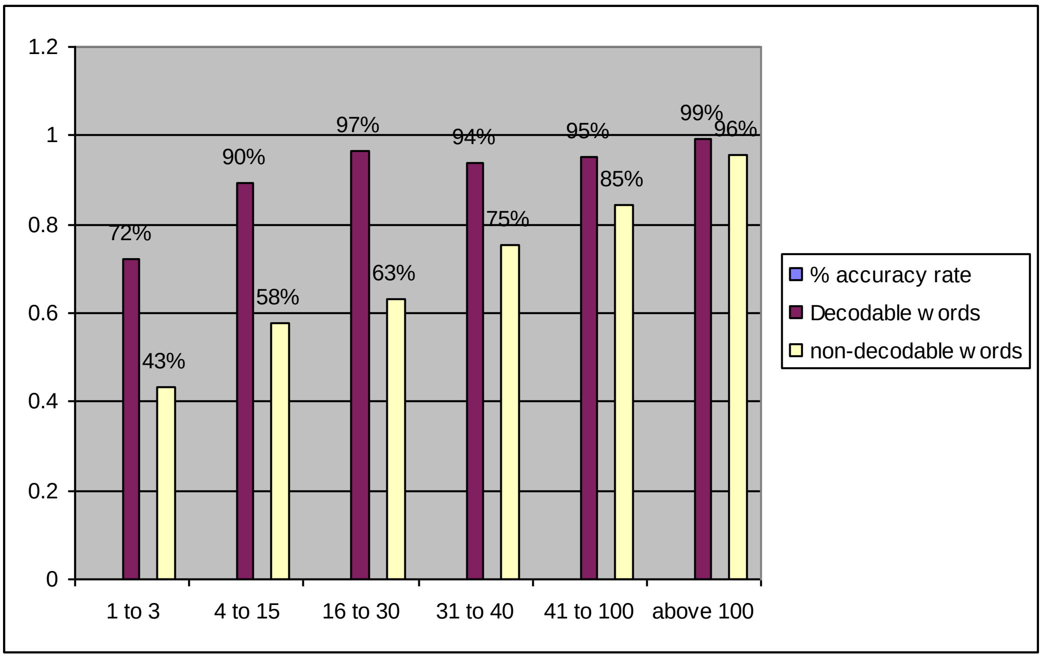
5.6.3 Analysis of recognition accuracy of words within children's phonic decoding ability (decodable words) and those that were not (non-decodable words)

Means and standard deviations for the accuracy rates of decodable and non-decodable words split into the six frequency bands and overall are shown in Table 5.9, with the bar chart based on these data shown in Figure 5.2.

Table 5.9: Accuracy rates for decodable and non-decodable words in each frequency band and overall

Frequency bands		1 to 3	4 to 15	16 to 30	31 to 40	41 to 100	Above 100	total
decodable	Mean	72.2%	89.5%	96.7%	94.0%	95.0%	99.5%	93.3%
	s.d.	39.0%	13.4%	5.9%	13.5%	9.9%	2.1%	15.8%
	No. of words	21	69	56	31	104	167	448
non-decodable	Mean	43.2%	57.7%	63.4%	75.4%	84.5%	95.6%	70.3%
	s.d.	29.2%	26.7%	19.2%	32.9%	14.9%	5.1%	28.5%
	No. of words	136	170	118	61	143	191	819

Figure 5.2: Accuracy rates of decodable and non-decodable words



Decodable words attained a mean accuracy rate of 89.5% for the frequency band from 4 to 15 repetitions, thus substantially exceeding the criterion of 78%. Decodable words were therefore considered to attain reliable recognition with as few as 4 to 15 repetitions, but not below that. The criterion level was not attained by non-decodable words until repetitions had exceeded 40.

The data were analysed with a two-way ANOVA with variables of frequency band and decodability, and letter length as a covariate.). A significant interaction effect was obtained ($F(5,124,)=4.176$, $p=0.002$).
The interaction was investigated using ‘simple main effects’, which show the differences in accuracy rates and significance levels separately for each frequency band. This showed that the differences in accuracy rates between decodable and non-decodable words were only significant in the lower three bands, varying in significance from $p=0.001$ to $p=0.004$. Once repetition levels exceeded 30 there was no significant difference between the accuracy rates of the two categories of word. Hence in relation to research question 2, significantly more decodable words were recognised up to 30 repetitions, and they are therefore considered to require less repetition to be learnt.

Main effects of frequency band and decodability were significant, respectively $F(5,124)=6.70$, $p<0.001$ and $F(1,124)=10.59$, $p=0.001$. The covariate was also significant ($F(1,124)=11.78$, $p=0.001$

Levene’s test of homogeneity of variance was significant ($p=0.049$). In these circumstances it is recommended that “you set a more stringent significance level for evaluating the results" (Pallant 2013 p.279). However, given the very high significance levels obtained, there was clearly a significant effect despite the violation of the assumption of homogeneity of variances.

5.7 Research question 3: Is less repetition required for content than function words?

5.7.1 Function and content words assessed in the research

The vocabulary tested in the research is shown in Table 5.10, split between function and content words and with the mean number of repetitions in the children's books shown alongside. The words have been organised starting with the highest frequencies at the top of the Table, with separate sequences for function and content words.

5.7.2 Contrasting properties of function and content words

As explained in the critical literature review, function words have different linguistic properties, as well as tending to be short and appearing at higher frequencies than content words. They are also felt to have low imageability. Several of these properties can be seen in the lists provided in Table 5.10. For instance, the general very high frequency of most function words is reflected in the mean average of repetition of words in the children's books, where much higher frequencies are shown for function words than content words.

There is a clear difference in the relative proportions of the two word types above 100 repetitions, with 59% (30/51) of the function words being at this level, compared to just 15% (20/130) of the content words. In addition, there are substantially more function words with very high repetitions, which may give them an advantage in the frequency band containing words above 100 repetitions, should this be associated with a higher accuracy of word recognition. This advantage, however, may be more than counterbalanced by the relative levels of words with high imageability.

Table 5.10: Words tested split between content and function words showing mean repetitions in books

Function words (51)				Content words (130)					
words	**reps**	**words**	**reps**	**words**	**reps**	**words**	**reps**	**words**	**reps**
the	2393.3	but	151.3	said	1311.0	Helen	42.0	horses	11.4
a	899.7	my	141.0	look	316.9	door	40.7	dug	11.3
and	840.1	not	133.6	little	304.0	donkey	39.6	pool	11.0
I	754.6	are	107.0	Mum	264.3	fish	37.9	Teddy	11.0
to	723.1	her	96.0	come	251.0	tortoise	37.6	pet	10.3
you	591.3	lets	86.1	go	248.0	park	36.9	Billys	9.7
in	554.0	all	84.9	get	187.3	has*	35.1	Alex	9.3
it	496.6	there	74.0	ran	173.1	sat	32.4	mole	9.1
is	490.4	did	71.4	like	169.6	green	32.4	sandwich	9.0
he	391.4	everyone	69.3	dog	158.6	lived	32.3	Jim	8.4
was	358.0	him	69.0	see	154.9	school	32.3	roll	8.1
here	345.0	some	66.4	Ben	153.3	find	30.0	doing	7.7
on	302.6	its	60.9	had*	148.0	grass	29.6	Bens	7.0
we	302.3	were	52.1	house	148.0	bus	29.3	nuts	7.0
will	279.7	something	39.3	have	144.6	Ted	29.3	lady	5.3
she	272.7	off	36.4	cat	137.7	gave	26.6	left	5.0
they	266.4	couldnt	36.3	play	133.4	ball	26.1	straw	5.0
at	245.6	who	35.6	got	119.3	bike	26.1	tails	5.0
this	229.4	over	30.9	stop	103.9	cross	26.1	hens	4.7
with	222.6	when	25.6	red	103.1	garden	25.6	heard	4.6
no	220.9	wont	12.7	children	92.1	two	25.4	jelly	4.6
out	209.1	would	9.1	mouse	91.9	black	24.7	splash	4.6
up	189.7	under	7.9	Sam	91.6	likes	24.4	clap	4.4
of	169.4	any	3.0	blue	90.1	morning	24.1	pink	4.4
what	168.7	youre	2.6	wanted	89.1	rabbits	24.1	skip	4.3
cant	153.0			pig	86.7	bag	23.3	downhill	4.0
				back	82.0	key	22.1	chicks	3.9
				Jennifer	75.3	cried	20.6	tiger	3.9
				fat	73.3	food	20.6	swimming	3.4
				going	68.9	hen	19.9	hotel	3.3
				yellow	68.0	climbed	19.6	foxes	2.9
				fast	65.9	rats	19.6	Annie	2.7
				duck	65.4	guess	18.0	sniff	2.1
				fox	65.3	paint	17.3	worked	1.9
				swim	62.0	Harold	17.0	trouble	1.7
				brown	53.0	feed	16.9	birds	1.6
				magic	51.1	greedy	16.1	bread	1.6
				fun	50.7	zoo	16.1	finding	1.4
				ride	50.4	Granny	15.4	lettuces	1.0
				car	48.1	barked	15.3	pictures	1.0
				think	47.7	cart	14.3	seat	1.0
				white	46.1	animals	13.6	standing	1.0
				Jill	45.4	parrot	11.9	worms	1.0
				Billy	44.9				

**Used as main verbs for possession, e.g. Granny had a garden.*

Many of the content words are concrete nouns, and even the verbs and adjectives in the main evoke sensory images. This contrasts strongly with the function words, where many words might be considered to fit Ehri's (1977) description of being relatively meaningless. The fact that function words tend to be shorter than content words is true for the words tested (average letter length of functors = 3.4, of content words = 4.7), but has been controlled for in the analysis by the use of a covariate of word length in letters.

In addition to these properties of the data visible in Table 5.10, there is an additional parameter which has not been taken into account, namely the extensive use of function words in children's written work. It is apparent that many of the function words listed are likely to be used repeatedly in children's writing. Although some of the content words listed may well appear often, particularly in descriptions of events at home (e.g. *mum, granny, house*), there is a far wider range of choice for content words, and frequencies may well be lower on average than function words. This would give a hidden advantage to the function words which have been used extensively in written work and learnt more effectively.

Thus there was no obvious prediction of which of the word types would require fewer repetitions and be more accurate in the frequency bands. Semantic variables favoured content words, but relative frequency could provide an advantage to function words, not just for those above 100 but, bearing in mind children's use of function words in written work, for the lower bands too.

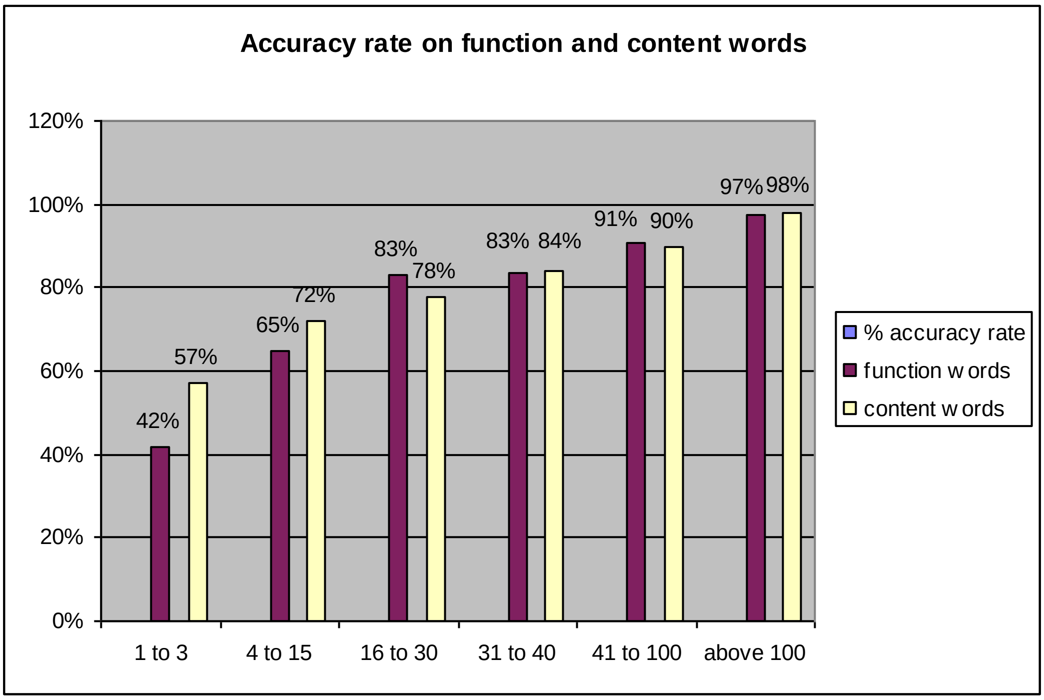
5.7.3 Analysis of recognition accuracy of function and content words

Means and standard deviations for the accuracy rates of function and content words split into six frequency bands and overall are shown in Table 5.11, with the bar chart based on these data shown in Figure 5.3.

Table 5.11: Accuracy rates for function and content words in each frequency band and overall

	frequency bands	1 to 3	4 to 15	16 to 30	31 to 40	41 to 100	above 100	Total
function words	Mean	41.7%	64.6%	83.0%	83.3%	90.8%	97.3%	81.6%
	s.d.	37.6%	25.9%	24.9%	35.6%	14.1%	4.2%	27.8%
	no. of words	12	22	24	13	72	214	357
content words	Mean	57.3%	71.9%	77.9%	84.1%	88.8%	97.7%	79.9%
	s.d.	33.2%	28.7%	20.4%	22.5%	13.3%	4.5%	25.2%
	no. of words	145	217	150	79	175	144	910

Figure 5.3: Accuracy rates of function and content words



Function and content words both attained the criteria of 78% in the frequency band from 16 to 30. Hence both could be said to need to exceed 15 repetitions before they are reliably recognised. This is in line with the whole sample of words, which also attained the criterion in the same band, hence there is no clear difference between the accuracy rates of the two categories.

The results were analysed with a two-way ANOVA with variables of frequency band and word class, with word length in letters as covariate. Level of repetition (i.e. frequency bands) and the covariate were significant, respectively $F(5,124)=8.64$, $p<0.001$ and $F(1,124)=58.63$, $p<0.001$, which simply reflects the progressive increase in recognition with an increasing level of repetitions, and the known effect of word length on young children's word recognition accuracy. Neither word class nor the interaction effect was significant, with results respectively of $F(1,124)=3.41$, $p=0.067$ and $F(5,124)=2.16$, $p=0.063$.

As the interaction effect approached significance, it was investigated using simple main effects. This showed that the accuracy rates for function and content words only differed significantly in the bands from 1 to 3 and above 100, with significance levels of $p= 0.009$ and $p=0.057$ respectively. The remaining four bands showed non-significant differences. This does not lend itself to an easy explanation, and has therefore been considered as a random variation, although the existence of unpredictable errors in the band above 100, discussed below, points to to one possible source, but 'unpredictable' is not an explanation.

Although function words did not emerge in the ANOVA as more difficult to recognise, i.e. requiring more repetitions than content words, in the logistic regression analysis described in detail at the end of this chapter, four short function words with high numbers of repetitions were 'outliers' in not being successfully recognised. They were to this extent unpredictably difficult for the three different children concerned and were *ipso facto* 'demon words', as referred to in one research paper (Aaron et al 1999). It may well be that such obvious difficulty in recognising what are, on the face of it, simple words has at least in part earnt them their reputation.

In relation to the research question as to whether content words required less repetition to attain reliable recognition, the answer is No. There was no clear difference in the amount of repetition required for the two categories of word.

5.7. Research question 4: Is less repetition required for mono-morphemic than multi-morphemic words?

The overall classification of the words into these two categories is shown in

Table 5.12.

Table 5.12: Mono- and multi-morphemic words

Mono-morphemic (121)				Multi-morphemic (60)	
a	go	parrot	white	animals	him
Alex	grass	pet	who	Annie	horses
all	green	pig	will	barked	is
and	guess	pink	with	Bens	its
any	Harold	play	yellow	Billy	left
are	have	pool	you	Billys	lets
at	he	red	zoo	birds	lettuces
back	Helen	ride		cant	likes
bag	hen	roll		chicks	lived
ball	here	Sam		children	my
Ben	hotel	sandwich		climbed	nuts
bike	house	school		couldnt	pictures
black	I	seat		cried	rabbits
blue	in	see		did	ran
bread	it	she		doing	rats
brown	jelly	skip		downhill	said
bus	Jennifer	sniff		dug	sat
but	Jill	some		everyone	something
car	Jim	splash		finding	standing
cart	key	stop		foxes	swimming
cat	lady	straw		gave	tails
clap	like	swim		going	Teddy
come	little	Ted		got	wanted
cross	look	the		Granny	was
dog	magic	there		greedy	were
donkey	mole	they		had	wont
door	morning	think		has	worked
duck	mouse	this		heard	worms
fast	Mum	tiger		hens	would
fat	no	to		her	youre
feed	not	tortoise			
find	of	trouble			
fish	off	two			
food	on	under			
fox	out	up			
fun	over	we			
garden	paint	what			
get	park	when			

5.8.1 Predicting the results of the comparison

The various types of multi-morphemic words were described and discussed in the critical literature review. They are split between inflected forms, derived forms and compound words. These subdivisions are shown in Tables 5.13 and 5.14.

Table 5 .13: Inflected words included in the multi-morphemic sample

Concatenated (28)		**Non-concatenated (17)**
regular plurals	**regular past tenses**	**irregular past tenses**
animals	barked	did
birds	climbed	dug
chicks	cried	gave
foxes	lived	got
hens	wanted	had
horses	worked	heard
lettuces		left
nuts	**present participles**	ran
pictures	doing	said
rabbits	finding	sat
rats	going	was
tails	standing	were
worms	swimming	would
irregular plural	**possessives**	**object pronouns**
children	Bens	her
	Billys	him
regular 3rd-person present		**irregular 3rd-person present**
likes		has
		is

As can be seen, the majority are inflected forms. Unfortunately, the only research located on this category relating to word recognition was carried out with adults. Reasons were provided in the literature review as to why it was likely that young readers might be sensitive to the morphological structure of words and possibly show some effects.

Within inflected words, concatenated and non-concatenated forms have been shown separately. The latter are considered by linguists to be multi-morphemic, even though many (including all those in this category in Table 5.13) are monosyllabic. Evidence demonstrating morphological effects of such words was described in the critical literature review.

Table 5.14: Derived and compound words and contracted forms

Derived words	Compound words	Contracted forms
Annie	downhill	can't
Billy	everyone	couldn't
Granny	something	it's
greedy		let's
Teddy		won't
		you're
Non-concatenated derived word		
my		

Overall, the literature described both advantages and disadvantages accruing to recognition of multi-morphemic words by reason of their morphemic structure, and made the predicted outcome of comparison with mono-morphemic words uncertain. In any case, as was pointed out in reviewing research on morphological effects, the contribution to word recognition is small in younger children. It only applies to a very restricted range of words, with the children's limited decoding skills as beginning readers felt to preclude wider effects. This was true of children a year older than the participants here, and hence the same minimal effect could be expected, or even no noticeable effect at all.

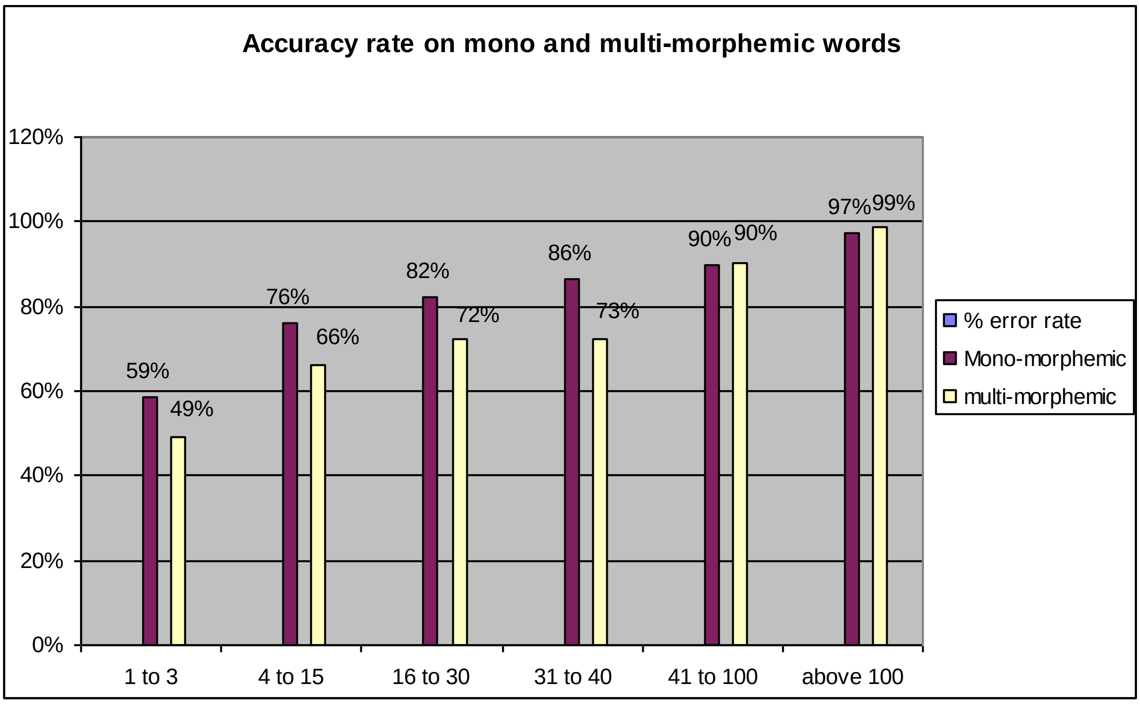
5.8.2 Analysis of the recognition accuracy of mono- and multi-morphemic words

Means and standard deviations for the accuracy of recognition of mono- and multi-morphemic words are shown in Table 5.15 split into the six frequency bands and overall, with the bar chart based on these data shown in Figure 5.4.

Table 5.15: Accuracy rates of mono- and multi-morphemic words, by frequency band and overall

	frequency bands	1 to 3	4 to 15	16 to 30	31 to 40	41 to 100	above 100	Total
mono-morphemic	Mean	58.6%	75.9%	82.3%	86.5%	89.6%	97.2%	82.0%
	s.d.	33.2%	27.3%	20.1%	21.7%	12.2%	4.4%	24.3%
	no. of words	64	134	108	69	182	290	847
multi-morphemic	Mean	49.1%	66.0%	72.2%	72.5%	90.0%	98.6%	76.2%
	s.d.	36.0%	32.1%	27.4%	41.6%	14.8%	5.3%	31.1%
	no. of words	93	105	66	23	65	68	420

Figure 5.4: Accuracy rates of mono- and multi-morphemic words



Mono-morphemic words attained the criterion of 78% for words repeated between 16 and 30 times, whereas for multi-morphemic words the criterion was not attained until repetitions exceeded 40. The difference in accuracy rates though, which suggested mono-morphemic words required fewer repetitions did not prove to be statistically significant. Results were analysed with a two-way ANOVA with variables of frequency and morphemic complexity, with word length in letters as a covariate. The only significant main effect was frequency bands (i.e. repetitions), $F(5,140)=4.42$, $p=0.001$. The covariate of letter length was also significant ($F(1,140)=76.12$, $p<0.001$).

Neither morphemic complexity nor the interaction effect was significant, with results respectively of $F(1,140)=0.65$, $p=0.42$ and $F(5,140)=0.57$, $p=0.73$. On the basis of the statistical analysis, with no significant difference between mono- and multi-morphemic words, the answer to research question 4 is no: mono-morphemic words do not require less repetition than multi-morphemic words.

Out of interest, the comparison was re-run with non-concatenated multi-morphemic words treated as mono-morphemic words. This produced significant main effects of morphemic complexity ($F(1,132)=10.41$, $p=0.002$) and frequency bands ($F(5,132)=5.95$, $p<0.001$). There was no interaction effect. The mono-morphemic words were recognised significantly more accurately than the multi-morphemic words, and hence required less repetition.

Thus, although in research studies morphological effects have been found for non-concatenated forms, their inclusion in multi-morphemic forms in the first analysis served to reduce the contrast with mono-morphemic words. The results shown in the bar chart, that multi-morphemic words require above 40 repetitions and that mono-morphemic words require above 15 repetitions to obtain reliable recognition, remained true when only concatenated words were included in the multi-morphemic sample. So in both cases this remains the approximate level of repetition required for instructional material.

5.8. Research question 5. What is the relative influence of repetition, word length in letters, decodability, word class and morphemic complexity on accuracy of word recognition?

Logistic regression was used to evaluate the relative impact of the independent variables listed in research question 5 on the dependent variable of word recognition accuracy. This approach as with linear regression, models the relationship in an equation with the value of coefficients for each predictor reflecting their relative contribution to changes in word recognition accuracy. Logistic regression is designed specifically for dichotomous dependent variables, in this case, whether the child was right or wrong in identifying a word. It is also much less exacting than linear regression in not requiring normal distribution of predictors. It was thus ideal for the calculation of the overall relative importance of the factors considered individually in the earlier research questions, many of which used categorical data (e.g. function versus content words).

The five predictors listed in the research question were entered in a single step. The model fitted the data and correctly classified over 80.3% of observations, 95.8% of errors and 23% of correct word recognitions. The logistic regression equivalent of R^2 square was 0.342. Table 5.16 shows the logistic regression coefficients, Wald test, and odds ratio for each of the predictors.

Table 5.16: Logistic regression predicting word recognition from level of repetition, decodability, word length in letters, morphemic complexity and word class

Predictor	B	S.E.	Wald	*p*	odds ratio
repetitions	.018	.003	46.72	<0.001	1.018
decodability	1.31	0.24	30.21	<0.001	3.69
word length	-0.24	0.061	15.35	<0.001	0.79
morphemic complexity	0.16	0.17	0.86	0.35	1.17
word class	0.06	0.23	0.057	0.81	1.06
Constant	1.26	0.39	10.22	0.001	3.53

Employing a 0.05 criterion of statistical significance, repetitions, decodability and word length in letters were all significant ($p<0.001$). Word class and morphemic complexity were both non-significant.

5.9.1 Problems with outliers

The Hosmer and Lemeshow test, which provides an evaluation of goodness of fit and should be non-significant with a level below 0.05%, was highly significant ($p<0.001$), and therefore indicated that there were problems with the model fitting the data. This can cause distortions in the analysis of results. The poor fit was caused by the extreme outliers shown in Table 5.17. The standardised residuals (z resid in the Table) are shown in s.d. units, and those above three s.d's should be very rare in a well-fitting model, hence the ones shown are indicative of problems.

Table 5.17: Extreme outliers with standardised residuals exceeding 5 s.d's

word	repetitions	Child ID	Z resid	word class
come	224	7	-9.38	content
got	84	21	-5.35	content
he	339	21	-34.43	function
no	167	21	-7.36	function
of	138	20	-10.90	function
pig	94	20	-6.33	content
they	344	16	-28.317	function

Of the seven shown, four were function words, all occurring at repetitions above 100, some substantially more. With just the four function words removed, and the analysis re-run, the Hosmer and Lemeshow test became non-significant (p=0.152). This suggests that the model was now a reasonable fit for the data. There is some debate among statisticians as to whether outliers should be included in the analysis, some favouring removal (Judd and McClelland 1989 cited in Osborne and Overbay 2004) and others favouring retention (Orr et al 1991 cited in Osborne and Overbay 2004). Tabachnick and Fidell (2013 p.77), an authoritative source, take the view that outliers should be retained "if they are properly part of the population from which you intend to sample". This was the case. As reported in the discussion of word class, teachers sometimes refer to function words as "demon words" as they can prove to be unpredictably difficult to learn for some children (Aaron et al 1999). As is apparent from the Table, errors occurred despite some very high levels of repetition so, although deviant from a statistical viewpoint, their existence is not considered atypical.

The approach therefore adopted was to re-run the analysis without the four function words and use this as a guide to likely results if there was no distortion caused by extreme outliers. This was then compared to the contributions of variables and significance levels which were obtained when the function words were left in. This provided some indication of possible distortion. (The Table with these results has been provided in appendix 13.)

In the analysis without the outliers, the same three predictors were significant at the same level of probability ($p<0.001$), with the two remaining predictors showing non-significant levels similar to the original analysis. The rank order of contribution of predictors also remained the same, as is discussed in the next section.

5.9.2 Contributions of the predictors

5.9.2.1 Contributions using the Wald test

The Wald test as shown in Table 5.16 provided one estimate of contributions. With the outliers left in the analysis, the three significant contributors were, in order of importance, level of repetitions, decodability, and word length in letters, with neither morphemic complexity nor word class proving to be significant. This remained the case with the outliers removed, but relative contributions altered, with repetition making a larger contribution. Contributions according to the Wald test for repetitions was 57.047 (with outliers in it was 46.72) while for decodability it was 27.60 (with outliers in, 30.21), making repetitions by far the most significant contributor in the analysis which excluded outliers. Word length was 17.20, not very different from the analysis with outliers in (15.35).

Hence it would appear that the distortion introduced by the outliers had the effect of reducing the importance of repetitions as a predictor, with minimal change to other predictors. The full logistic regression table showing the logistic regression coefficients, Wald test, and odds ratio for each of the predictors, once outliers were removed, has been provided in appendix 13.

5.9.2.2 Contributions using the likelihood ratio

Tabachnick and Fidell (2013) consider the likelihood ratio, which is also used to assess contributions, to be superior to the Wald test reported in the preceding section. The latter can be overly conservative. In the likelihood ratio approach the improvement in the overall model is computed by adding a single predictor in a final step. This was carried out for the two analyses, one with the outliers in and the other with the outliers removed. The results are shown in Table 5.18.

Table 5.18: Log likelihood estimation of contributions

Predictor	Outliers in		Outliers removed	
	Log likelihood	*p*	Log likelihood	*p*
repetitions	97.03	<0.001	124.24	<0.001
decodability	35.00	<0.001	31.78	<0.001
word length	15.44	<0.001	17.37	<0.001
morphemic complexity	0.85	0.36 ns	0.51	0.48 ns
word class	0.06	0.81 ns	0.16	0.69 ns

In terms of the overall pattern of results, it is very similar to that shown by the Wald tests. Hence the answer to the research question is that, in order of importance, the significant contributors were repetitions, decodability and word length, with a larger contribution from repetitions when the outliers were removed. For both analyses neither morphemic complexity nor word class was significant.

Chapter 6 Summary and conclusions

6.1. Overview

The results of each research question are described, together with their possible significance and relationships with other research. Limitations of the study are discussed, as well as possible implications for reading schemes for young readers.

Discussion

6.2. Overall number of repetitions

Research question 1. Are four repetitions of words sufficient for them to be read subsequently at 78% level of accuracy?

Clearly, the widely accepted notion that four repetitions are sufficient to learn to recognise words reliably was not true for this group of five- and six-year-old English children, who all scored at average or above-average levels on reading tests. Learning to recognise new words, at least when the source is reading scheme books, is not ‘spongelike’ (Adams 1990), and overall, for the vocabulary assessed, required between 16 and 30 repetitions to attain the level expected for reliable recognition. As pointed out by Juel and Minden-Cupp (2000), in books, content words may appear very infrequently, and for learning to be durable may well require substantially more repetitions than for the short-term retention investigated in the experimental studies from which the figure of four repetitions originated.

Evidence that durability of learning is associated with increased repetition ‘overlearning trials’ has been demonstrated in third-grade American children (Lemoine et al 1993), and seems to have been true of the fourth-grade children shown to retain their learning after 10 weeks in the well-known study by Hogaboam and Perfetti (1978).

In view of the fact that many English reading books have vocabulary ‘dramatically skewed towards the lower frequencies’ (Masterson et al 2010 p.227), there will need to be some recognition by publishers of the minimal retention likely for many of the words in texts designed to teach children to read. Certainly the need for repetition may need to be recognised if selections of real books are used (Solity and Vousden 2009), and some form of database maintained to ensure the ones provided to children address this dimension.

6.3. Decodability

Research question 2: Is less repetition required for words that are within the children’s phonic decoding abilities?

From the assessments used, it appeared that the majority of children had learnt only those grapheme-phoneme correspondences explicitly taught, with the vowel digraphs which had not been covered not capable of being decoded. Words that were within the children’s phonic decoding abilities required less repetition to be recognised reliably than those that were not, the former attaining the criterion for familiar words when they had appeared between four and 15 times in books, whereas the latter required between 41 and 100 repetitions. This provided a rough estimate for levels of exposure required in instructional material. As predicted in relation to the research question comparison, there was an interaction effect, with the difference in accuracy rate between the two word types only being significant in the lower bands from 1 to 30 repetitions and the bands above 30 showing no significant difference.

The children's phonemic awareness, as reflected in their segmentation and blending ability, coupled with their knowledge of letter sounds, was clearly linked to their knowledge of gpc's. As the results indicated, such knowledge had a powerful effect on the repetitions they required to learn 'decodable' as opposed to 'non-decodable' words. Thus not only do phonemic ability and knowledge of letter sounds aid children in learning words from the very earliest stages of their reading career (Dixon et al 2002, Stuart et al 2000), but they continue to have a significant impact as their decoding skills develop.

It has been known for some time that knowledge of gpc's gives beginners a substantial advantage in reading unfamiliar words containing them (Jeffrey and Samuels 1967, and Carnie 1977, both quoted in Ehri 1991). But, as Hiebert and Martin (2009) pointed out, simply having texts which match the content of phonics-based programmes without due attention to repetition is not always successful in teaching children the words they contain.

Fortunately, the school books read by the children in the dissertation research in their first year of instruction had high repetition of words containing single vowel letters with their short sounds. These were among the gpc's they were taught, and were those which they could decode on assessment. The repetitive vocabulary probably also played a significant role in the children's learning of the phonic rules. It seems to follow logically that, whilst children are learning a new gpc, the level of repetition of vocabulary intended to practise its recognition will need to be at the level for 'non-decodable' words until the skill is acquired.

6.4. Word class

Research question 3. Is less repetition required for content than function words?

Research findings show that children find function words harder to learn than content words (Stuart et al 2000), and tend to be less accurate in recognising them (Aaron et al 1999). This did not prove to be the case for the research comparison, where there was no significant difference in accuracy, and both categories required between 15 and 30 repetitions to attain reliable recognition. It was, however, pointed out, whilst discussing the likely outcome of the comparison in chapter 5, that function words may have a hidden advantage of being more frequent than content words in the children's own writing, and even some of those appearing at lower (5 to 40) repetitions in the books could fall into this category (e.g. *who, under, when, off*). This could well provide sufficient additional opportunities to improve their recognition accuracy to mask the normal advantage associated with content words.

6.5. Mono- and multi-morphemic words

Research question 4. Is less repetition required for mono-morphemic words than multi-morphemic words?

Mono-morphemic words attained the criterion for reliable recognition for items repeated between 16 and 30 times, whereas multi-morphemic words did not attain this until repetitions exceeded 40. The difference in accuracy rates between them was, however, not statistically significant. The answer to the research question, therefore, was that mono-morphemic words did not require fewer repetitions to be learnt.

There was, however, a somewhat varied mixture of words considered multi-morphemic by linguists. They included some non-concatenated irregular past tense verbs (e.g. *saw, ran*). When all of these were removed and treated as mono-morphemic, there was a significant difference in accuracy favouring the mono-morphemic words. The frequency band data for this altered analysis indicated that reliable recognition was attained in the same bandings as in the original analysis (i.e. 16 to 30 for mono-morphemic and above 40 for multi-morphemic).

The accuracy advantage for mono-morphemic words shown in the frequency band data conflicts with findings from second graders in the Carlisle and Stone (2005) study, where multi-morphemic words were read more accurately than matched mono-morphemic words (e.g. *windy* v *candy*). No such matching was carried out for words used in the dissertation research. The major difference, however, was that Carlisle and Stone studied derived words, whereas the majority of words in the multi-morphemic sample in this study were inflected words. Adults find these harder to recognise than their mono-morphemic stems (New et al 2004, Sereno and Jongman 1997).

Hence the result with only concatenated words treated as multi-morphemic could be in line with this result, showing mono-morphemic words to require less repetition. However, there is no equivalent child-based research on word recognition of inflected forms and, given that the sample included derived words, compound words and contracted forms, any conclusion would be far from clear.

6.6. The regression analysis

Research question 5. What is the relative influence on word recognition accuracy of level of repetition, decodability, word length in letters, word class, and morphemic complexity?

The order of importance of the factors entered in the regression equation was repetition, followed by decodability, and word length in letters. All were highly significant ($p<0.001$). Morphemic complexity and word class were last in order of importance, and neither was significant.

There are some interesting comparisons to be made between the relative importance of contributions made by repetition and decodability for the dissertation children and the same factors also used in a regression equation in the study by Juel and Roper/Schneider (1985). The latter produced two separate regression equations, one for a group who were reading a series of early books with low repetitions of words of which many were irregular (Houghton-Mifflin), and another with more repetition and a higher proportion of regular words (Economy series).

For both sets of children, repetition and decodability were the highest contributing factors to word recognition accuracy, with similar levels of statistical significance (p=0.01). However, there were differences in the factors' relative contributions, which seemed to relate to the content of the texts read. The group on the Economy series, felt by the researchers to be using a phonic strategy, had decoding as the largest contributing factor, whereas children on the Houghton-Mifflin series, felt to be using a visual strategy, had repetition as the largest contributor. This was a similar result to the children in the dissertation research, where repetition was the largest contributor in the logistic regression equation. The implication would seem to be that these children also may have been using a visual strategy, possibly encouraged by the vocabulary content of the mixture of schemes they had read.

Two of the schemes used by the children (Ginn and Oxford Reading Tree) are included in the children's printed word database (Masterson et al 2010) and are characterised by high numbers of low-frequency words, many of which were beyond the children's decoding ability. A good number of the words with reasonable levels of repetition were also 'non-decodable'. Hence the very high reliance on repetition demonstrated in the logistic regression equation may have been a strategy encouraged by such texts.

As Juel and Roper Schneider (1985 p.137) comment, "even though children are taught a 'sound the word out' strategy, they will adopt a predominantly visual strategy… if the texts to which they are exposed contain many words that are not easily phonologically recoded."

The implication would seem to be that, even though repetition is an important factor for books designed to teach children to read, it is equally necessary to ensure a goodly proportion of vocabulary which allows children to make use of their existing knowledge of phonics.

On the basis of the results for research question 2, this should allow acquisition of new vocabulary with fewer repetitions. Equally, if more gpc's are taught with the current increased emphasis on synthetic phonics (D*f*ES 2007), the proportion of words decodable by children should increase, producing a more balanced contribution for decodability and repetition.

6.7. Limitations of the study

6.7.1 The assessment of decoding skill

There were two problems here, a ceiling effect on the segmentation and blending tests, and a very small range of nonwords used to evaluate gpc's capable of being decoded by the children.

The blending and segmenting tests extended to CCVCCs, which most children found difficult to remember. Hence to increase their length by including triple consonant clusters (as in *splash*) seems to just add a memory load. Deletion tests (e.g. 'Say /trɪp/ without the /r/ sound'), although known to be more difficult, are also felt to reflect existing orthographic knowledge, rather than just assessing phonemic awareness (Byrne and Fielding-Barnsley 1993).

The blending test did provide a sufficient range of scores to differentiate between children, and this could have been extended to include a large number of different words at the levels which children began to find difficult (i.e. CVCC, CCVCC) without increasing the number of sounds they needed to recall. In addition it would have been useful for the nonword test to provide items which paralleled the CVCC and CCVCC structures covered in the segmentation and blending tests, and also for its range of vowel sounds to be increased. This would have made the decision on the children's existing phonic decoding skills easier, and possibly more reliable.

6.7.2 Comparison of function and content words

There was a restricted range of function words in the lower frequency bands (10 different words only between one and 39 repetitions). This resulted in there being a very limited selection for the comparison. It would seem sensible to ensure that in any replication, a wider range of function words was included to provide a sound basis for comparison with content words.

6.7.3 Comparison of mono-morphemic and multi-morphemic words

There was a very diverse sample of multi-morphemic words. Given the restricted range of such vocabulary in research on morphological effects on children, a more limited selection (e.g. only derived words) might provide a clearer basis for comparison.

6.8. Limitations on generalisability

6.8.1 The number of children in the study

Although envisaged as a pilot study, it had been intended to include more children. The very small numbers put all conclusions at the level of informed speculation. It served, however, to demonstrate the feasibility of using real-world data both to provide practical information on existing instructional materials as well as investigating more theoretical issues. The variety of vocabulary assessed, however, does mean that the conclusion about the strong relationship between accuracy of word recognition and level of repetition in books was underpinned by an extensive sample of words.

6.8.2 Children's phonic decoding skills

The children's knowledge of gpc's seemed to relate quite strongly to the syllabus taught at the school, which was based on the National Literacy Strategy in force in England at that time (2006/07).

The government recommendations for phonics teaching (D*f*ES 2007) later extended this considerably, and the detailed results of phonic screening carried out in UK schools in 2013 (D*f*E 2014) showed that over 90% of Year 1 children were successful in reading nonwords which included vowel digraphs <ee> and <or>, neither of which was taught by the end of the second term in Year 1 in 2006/07, when the dissertation research took place. Hence it appears children's decoding skills are beginning to reflect the new phonics syllabus. With this in mind it would appear that the results of the dissertation which related to children's decoding skills covered a more limited range of gpc's than children recognise in 2014. If words containing gpc's children could decode require fewer repetitions than those containing gpc's they could not, as demonstrated in the research, then a larger proportion of words may be learnt more rapidly by similar age children in 2014.

Hence, although one may be able to generalise about the relative difficulty of the two categories of words, the vocabulary that is decodable may have increased in line with children's new phonic skills.

6.8.3 Reading schemes in use

The texts used by the dissertation children were in fact partly replaced by their school with new schemes the year after the research terminated. Such new books would probably have different levels of repetition, and might have produced different results. Such variation would be true of any school using a different range of books and, with many publishers now producing ‘decodable texts’ which focus on phonic skills, variability from the books used in the research seems highly likely, with consequent limitations in applicability of some of the findings.

6.8.4 The teaching environment

The school was in a small market town in Derbyshire. It strongly encouraged parent participation in the teaching of reading, and most parents read with their children at home 4 to 6 times a week. In addition, every child read to an adult for a few minutes each day whilst at school. All these parameters no doubt played a part in the dissertation children’s levels of skill and the repetitions they required to learn words, with consequent limitations on the generalisability of the results to other schools.

6.9. The dissertation research and comments on the design of reading schemes

One clear message from the research was that it was only those words that were within the children’s phonic decoding ability that reached the criterion for reliable recognition with very few repetitions, that is, in the band from 4 to 15. Words which were beyond the children’s decoding ability required considerably more, not attaining the criterion for reliable recognition until repetitions exceeded 40. Thus the need for high repetitions with such words adds to a similar finding in Stuart et al's (2000) study also conducted with young English children, in their case in the reception year.

The phonic skills that the children in the dissertation study had learnt could be practised with many words in the books that were provided in their first year of reading. The fact that the skills had been learnt has parallels with the seminal study of Juel and Roper/Schneider (1985), where it appeared that, not only did phonics objectives require explicit teaching, but they also required an extensive sample of words in reading books which were decodable using the skills taught.

It would seem that repetition is a critical parameter, not just overlooked but almost counter-cultural, where prevailing wisdom is that words require very few repetitions even for young readers. The message from this small pilot study is that this initially applies only to a small sample of words which children can decode, and to ensure optimal impact of early instruction high levels of repetition are an essential component of texts designed to teach children to read, and indeed to establish the phonic skills which will move children in the direction of requiring minimal repetitions for 'decodable' words. This needs to apply to the words which embody the early phonic skills being taught. One would hope that this could be implemented by their inclusion across a wide range of different books rather than reverting to the stilted English of a bygone era.

Finally, the research design itself, if extended to cover a larger number of participants and if the changes suggested in the assessments detailed in this chapter were implemented, could allow for systematic evaluation of teaching materials widely used in helping children learn to read, permitting evaluation of the effect of level of repetition and the development of specific phonic decoding skills. A more careful selection of function words and multi-morphemic words would enable better comparisons to be made of relative levels of repetition required for these word types to be learnt, thus extending the evaluation of influences on word recognition in beginning readers. This would be very much in line with the modern-day emphasis on evidence-based practice (Snowling and Hulme 2011).

6.10. A final word

Above all, what this study has shown is that, for at least some children and some types of word, acquisition is not ‘spongelike’.

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Index to Appendices

Appendix 1: Calculating the criterion for reliable recognition based on Seymour et al (2003)

The criterion for reliable recognition for the mixture of content and function words used in the dissertation research was based on the recognition accuracy obtained by Seymour et al (2003) for a group of 6-year-old Scottish children. There were, however, differences in the relative proportions of function and content words used with the Scottish children and those used in the dissertation research. This required a minor adjustment.

Seymour et al obtained a mean percentage accuracy of 73.70 for 18 function words and 79.07 for 18 content words. With the equal proportions of words (i.e. a 1:1 ratio), it was just necessary to add the two means together and divide by 2 to obtain the overall mean for mixed content and function words: $(73.7+79.07) \div 2 = 76.39$. This was the combined rate for function and content words quoted in the paper.

It was necessary to weight the calculation to obtain the combined rate for the dissertation research, where there were 51 function words and 130 content words giving a ratio of 1:2.54. To obtain the combined rate the mean percentage for function words taken from Seymour et al was added to their mean rate for content words X 2.54, and the total divided by 3.54: $(73.7 + (79.07\times2.54)) \div 3.54 = 77.55$. This combined rate of 77.55% was rounded to 78% in use for all research questions in the analysis.

Appendix 2: Books in the reading scheme with sequence of reading blocks indicated by block number

Block 1 - Ginn pre-readers

Animals That Hide
Baking
Ben
Butterfly
Day Puppy Got Lost
Digger
Egg
Fire
Frog Spell
Hard Days Shopping
Help
Here
Home
In The Garden
Is This My Home
Kings Sock
Lad
Living In The Gardens
Look
Look Where I Live
Lost
New Home
Odd One Out
On My Bike
Parade
People Who Help Us
Pirate Treasure
School Fair
What's In Here
Where Is It
Where Is My Bone
Where Is The Monster

Block 2 - Ginn Level2

At Night
Can You
Hide And Seek
Where Is Jill
Come For A Ride
Can You See Me
Swim At The Park
Ben And Duck
Come And Play With Me
Come For A Swim
Liz And A Digger
Somewhere To Play
Waiting For Tom
Watch That Cat
Ducks Day Out
Jill's Baby Brother
You Can't Get Me
Celebrations
Playing In The Park
Fun At The Swimming Pool
Animals At Home
Can We Play
Where Are You Going
Bath
Can We Help
Look Like Me
Bee
I Can Hide
Up We Go

Block 3 - Oxford Reading Tree Stage 1

At The Park
Big Feet
Fancy Dress
Go Away Cat
Go Away Floppy
Go On Mum
Goal
Good Old Mum
Headache
Hide And Seek
Journey
Kippers Diary
Look After Me
Look At Me
Making Faces
Pet Shop
Present For Dad
Push
Reds And Blues
Shopping
Top Dog
What A Mess
What Dogs Like
Who Did That

Block 4 - New Way White

At School
Birthday
Birthday Presents
Bookshop
Fat Fox
Handstand
I Can
I Can Paint
I Can Read
Lots
On The Mat
Picnic
Sand Picnic
Sandwich Box
Sandwiches
Shoe Shop
Tails
Who Are You

Block 5 - Oxford Reading Tree Stage 2

Babysitter
Biff's Aeroplane
Chase
Dream
Floppies Bath
Floppy The Hero
Foggy Day
Go-Kart
Kippers Balloon
Kipper's Birthday
Kippers Laces
New Dog
New Trainers
Spots
Toys Party
Water Fight
What A Bad Dog
Wobbly Tooth

Block 6 - Oxford Reading Tree Stage 3

At The Pool
At The Seaside
Band
Barbecue
Book Week
Bull's Eye
By The Stream
Carnival
Cat In The Tree
Cold Day
Creepy Crawley
Dolphin Pool
Hey Presto
It's The Weather
Jan And The Anorak
Jan And The Chocolate
Joe And The Bike
Jumble Sale
Kipper The Clown
Kippers Idea
Little Dragon
Lost Puppy
Midge In Hospital
Monkey Tricks
Naughty Children
New Trees

Nobody Wanted To Play
On The Sand
Pip At The Zoo
Rope Swing
Roy And The Budgie
Sinking Feeling
Snowman
Strawberry Jam
Up And Down
What Is It

Block 7 - 1,2,3 and Away

Benjamin And The Witch And The Donkey
Big Dog And A Little White Cat
Billy Blue Hat
Billy Blue Hat And The Frog
Crash The Car Hit A Tree
Dog And The Ball
Donkey Went To Town
Jennifer A Yellow Hat Went Out In The Sunshine
Jennifer And The Little Dog
Jennifer And The Little Fox
Jennifer In The Dark Woods
Jennifer Yellow Hat Went Out In The Dark
Jennifer Yellow Hat Went To Town
John IAnd Jennifer Yellow Hat
Kite That Blew Away
Little Brown Mouse And The Apples
Little Brown Mouse Went Out In The Dark
Little Old Man And The Donkey
Little Old Man In The Little Brown Mouse
Little Old Woman
Magic Wood
Miranda And The Dragon
Miranda And The Flying Broomstick
Miranda And The Magic Stones
Mrs Blue Hat And The Little Black Cat
Mrs Blue Hat And The Little Brown Mouse
Mrs Blue Hat And The Red Cart
Mrs Rigg And The Little Black Cat
Old Blue Bus
Old Man
Old Man And The Seven Mice
Percy Green
Percy Green And Mr Red Hats Car
Percy Green And Mrs Blue Hat
Ramu And Sita And The Robber
Rips Bath
Roger And Mrs Blue Hat
Roger And Rip
Roger And The Little Mouse
Roger And The Pond
Roger Has A Ride
Roger Red Hat
Roger The Stick And The Old Man
Sita And Ramu
Sita And The Little Old Woman
Witch And The Donkey

Block 8 - Ginn Level 3

Babies
Babysitter
Can I Come With You
Digger At School
Doghouse
Dolly's Magic Brolly
Don't Run Away
Duck Is A Duck
Duck Trouble
Fast And Slow
Find The Key
Going To The Shops
Good Book
Good Read
Grass
Guess What Cat Found
Harold
Horses
I Can Read
Let The Dogs Sleep
Little Rabbit
Lost And Found
No School Today
Noah's Ark
Park
Picnic For Tortoise
Play A Play
Reindeer
Sparky The Dragon
Tom Looks For A Home
Tortoises
Where Are You Going
Where's Little Ted
Work And Play

Block 9 - New Way-Pink

At The Fair
Ben's Book
Better Than You
Big Fish
Big Win
Day By The Sea
Debs Book
Fat Pigs Book
Fat Pigs New-Car
Fun Run
Ice Cream Van
In The Pot
Jip’s Book
Kim's Little Friend
Kim's Pet
Lion Is Ill
Meet The Friends
Meg's Book
Not For Me
Race
Ring Ring
Robs Caterpillar
Roll Over
Sam's Book
Spots
To The Moon And Back
Two Folktales
Two Short Stories
What's For Dinner

Block 10 - New Way Red Level

A Is For Apple
Adams Bike
Ben's Bone And At The Dentist
Bike For Five
Bone
Dragon's Egg
In The Tree
Kim Can't Come
Little Brown Dog
Little Red Hen And The Water Snake
My Cat And A Rainy Day
My Horse Can Fly
Pat The Pig's Birthday
Playtime And Sam Goes To The Hospital
Rats
Snow House
Super Pig And Jip The Pirate
Sweets

Three Little Pigs
Tigers Birthday
Toy Box
Treasure
Two Fables
Two Traditional Tales
What A Mess And The Little Elephant
What Can We Do
Yum Yum

Block 11 - Oxford Reading Tree Stages 4 & 5
Balloon
Camcorder
Come In
Dragon Dance
Everyone Got Wet
Flying Elephant
House For Sale
New House
Nobody Got Wet
Play
Poor Old Mum
Scarf
Secret Room
Storm
Swap
Weathervane
Wedding
Wet Paint
Stage 5
Adam Goes Shopping
Adam's Car
Camping Adventure
Castle Adventure
Dragon Tree
Gran
Great Race
It's Not Fair
Joe And The Mouse
Lucky The Goat
Magic Key
Midge And The Eggs
Monster Mistake
Mosque School
Mum To The Rescue
New Baby
New Classroom
Noah's Ark Adventure
Pip And The Little Monkey
Pirate Adventure
Roy At The Fun Park
Scarecrows
Sun Ship
Underground Adventure
Vanishing Cream
Village In The Snow
Whatsit
Yasmin And The Flood
Yasmin's Dress

Block 12 - Ginn Level 4
About Helicopters About Animals
Animal Friends
At The Zoo
Ben Goes To School
Big One Will Eat You
Book For Kay
Boy With The Shell
Crash Landing
Get That Fly
Going Away Bag
Helicopters
I'm A Good Boy
Little Monkey
Mums Birthday Surprises
Mums Surprise Ride
New Boy At School
Once Upon A Time
Sam And Sue At The Seaside
Sam And Sue At The Zoo
Save The Animals
Special Book For Jill
What A Surprise
What Can We Do
Who Took My Money

Block 13 - New Way Green
Bad Apple And The Carrot Field
Bad Cow
Big Head And The Greedy Dog
Billy Goats Gruff
Camping Holiday
Deb's Secret Wish
Film Star
Goodbye Little Red Hen
Hello
It's Not Fair
Little Red Hen
Magic Swan
New Tie
No Rain No Water
Paper Boy
Postcard
Princess Helen
Red Doll
Rob Goes To Hospital And Get Well Soon
Secret And The Birthday Surprise
Shoe Laces
Silly Parrot
Three Kings And Kim's Star
Three Pots Of Gold
Tim And Tom And Who Will Push Me
Two Animal Stories

Block 14 - 1,2,3 and Away-Dark Green
Big Man The Witch And The Donkey
Billy Blue Hat And The Duck Pond
Cat And The Feather
Caterpillars And Butterflies
Gopal And The Little White Cat
Little Old Man And The Little Black Cat
Little Old Woman And The Grandfather Clock
Old Man And The Wind
Roger And The Ghost
Roger And The Old School Bus
Sita Climbs The Wall
Village With Three Corners
When The School Door Shut

Appendix 3: List of words assessed, with children's exposure

Child ID	1	7	8	16	20	21	23
a	992	818	1210	1070	655	622	931
Alex	11	14	7	2	11	6	14
all	64	67	155	136	53	51	68
and	858	686	1189	1058	626	621	843
animals	2	2	40	44	3	2	2
Annie	2	1	6	2	1	2	5
any	2	3	4	5	4	2	1
are	92	86	173	163	68	77	90
at	273	199	364	297	170	153	263
back	78	66	126	110	49	63	82
bag	17	19	37	45	13	13	19
ball	19	23	37	45	21	17	21
barked	24	15	16	13	13	13	13
Ben	179	107	175	180	132	106	194
Bens	7	6	7	8	7	6	8
bike	21	20	38	19	22	27	36
Billy	40	42	52	54	42	42	42
Billys	10	10	8	10	10	10	10
birds	1	1	3	3	1	1	1
black	22	25	25	26	24	24	27
blue	95	86	83	88	93	90	96
bread	1	1	5	1	1	1	1
brown	55	61	47	60	44	52	52
bus	33	19	28	29	31	32	33
but	152	108	239	201	100	106	153
cant	161	123	200	202	122	110	153
car	53	37	53	62	26	47	59
cart	19	17	16	7	11	10	20
cat	135	143	163	156	119	126	122
chicks	5	1	5	5	5	1	5
children	128	68	144	121	34	28	122
clap	9	1	1	9	9	1	1
climbed	28	18	29	13	15	13	21
come	238	224	343	330	177	187	258
couldnt	52	33	46	36	24	27	36
cried	18	27	14	17	25	14	29
cross	24	26	33	33	20	19	28
did	71	45	100	103	51	63	67
dog	161	173	170	166	144	157	139
doing	8	7	15	11	1	5	7
donkey	40	40	37	40	40	40	40
door	46	44	55	43	32	25	40
downhill	4	3	5	4	3	4	5
duck	71	77	95	54	38	44	79
dug	9	9	10	19	18	5	9
everyone	84	76	89	70	47	44	75
fast	73	58	91	86	44	49	60
fat	96	39	82	80	74	77	65
feed	15	13	27	21	12	15	15
find	44	18	52	38	5	29	24
finding	2	1	1	2	1	2	1
fish	46	25	44	52	32	26	40

Child ID	**1**	**7**	**8**	**16**	**20**	**21**	**23**
food	14	13	35	26	22	20	14
fox	86	33	88	74	48	51	77
foxes	4	3	4	1	3	2	3
fun	57	32	84	70	34	34	44
garden	31	14	45	33	7	27	22
gave	32	30	34	22	19	18	31
get	201	151	247	260	131	147	174
go	255	205	340	345	184	185	222
going	66	54	103	119	27	60	53
got	128	99	177	153	82	84	112
Granny	20	3	31	20	3	11	20
grass	49	14	57	18	11	45	13
greedy	11	10	20	20	20	20	12
green	34	27	24	38	33	33	38
guess	20	17	28	16	12	19	14
had	164	141	187	168	107	116	153
Harold	29	1	29	29	1	1	29
has	35	30	54	53	22	22	30
have	166	104	224	221	73	124	100
he	411	323	523	479	275	339	390
heard	7	1	8	1	1	7	7
Helen	41	38	60	61	28	17	49
hen	26	17	28	25	19	10	14
hens	5	3	6	6	3	5	5
her	101	82	151	123	59	68	88
here	311	300	466	418	334	288	298
him	66	61	90	88	44	59	75
horses	11	9	20	23	1	8	8
hotel	5	5	1	1	1	5	5
house	152	132	190	156	123	120	163
I	804	628	1042	967	581	562	698
in	587	460	740	651	453	447	540
is	496	357	679	595	439	420	447
it	521	422	725	619	382	329	478
its	75	29	102	95	26	25	74
jelly	5	6	5	7	3	3	3
Jennifer	73	81	71	71	81	73	77
Jill	45	39	73	38	33	39	51
Jim	7	7	7	17	7	7	7
key	38	2	29	42	1	11	32
lady	6	4	8	4	2	4	9
left	5	5	5	5	5	4	6
lets	86	67	118	111	59	72	90
lettuces	1	1	1	1	1	1	1
like	170	162	271	227	127	87	143
likes	26	17	45	33	13	16	21
little	313	275	392	352	248	245	303
lived	31	30	38	36	29	28	34
look	293	268	418	383	311	243	302
magic	59	24	84	76	24	20	71
mole	6	2	8	16	16	8	8
morning	25	12	45	39	1	22	25
mouse	92	75	119	113	55	85	104
Mum	279	229	419	339	155	158	271

Child ID	**1**	**7**	**8**	**16**	**20**	**21**	**23**
my	148	103	205	173	100	126	132
no	234	180	299	261	177	167	228
not	142	101	180	170	110	111	121
nuts	7	7	7	7	7	7	7
of	165	154	229	205	138	137	158
off	44	34	54	38	16	29	40
on	339	268	400	362	206	225	318
out	224	173	264	257	159	187	200
over	38	23	44	32	29	15	35
paint	24	27	30	20	6	5	9
park	45	33	51	40	29	26	34
parrot	4	4	30	35	4	3	3
pet	15	7	10	11	11	14	4
pictures	1	1	1	1	1	1	1
pig	106	49	91	94	94	92	81
pink	9	1	3	9	3	3	3
play	145	114	182	149	114	98	132
pool	13	12	13	12	7	10	10
rabbits	33	16	39	27	13	17	24
ran	175	151	209	197	143	149	188
rats	20	20	20	20	19	19	19
red	101	96	108	112	105	86	114
ride	52	42	75	69	31	39	45
roll	11	1	11	11	11	1	11
said	1395	977	1885	1688	916	917	1399
Sam	93	57	119	106	85	88	93
sat	33	30	41	33	29	27	34
sandwich	5	18	10	20	4	4	2
school	35	22	55	47	11	19	37
seat	1	1	1	1	1	1	1
see	159	110	233	215	109	107	151
she	305	254	356	323	188	183	300
skip	5	3	6	6	4	2	4
sniff	9	1	1	1	1	1	1
some	66	51	110	85	45	51	57
something	42	27	75	65	1	35	30
splash	5	5	5	4	4	4	5
standing	1	1	1	1	1	1	1
stop	99	80	135	124	96	87	106
straw	5	5	5	5	5	5	5
swim	67	66	89	70	44	36	62
swimming	4	4	4	4	3	3	2
tails	2	2	3	13	12	1	2
Ted	40	28	59	22	8	17	31
Teddy	11	11	11	11	11	11	11
the	2604	1936	3331	2843	1737	1769	2533
there	78	54	113	103	47	59	64
they	317	210	419	344	136	132	307
think	44	32	78	76	23	37	44
this	235	202	339	289	181	154	206
tiger	1	6	6	6	6	1	1
to	740	594	1098	974	420	539	697
tortoise	47	42	49	22	22	39	42
trouble	2	2	2	1	2	2	1

Child ID	**1**	**7**	**8**	**16**	**20**	**21**	**23**
two	27	14	30	38	24	17	28
under	8	6	13	14	4	4	6
up	207	152	270	230	122	145	202
wanted	105	92	120	101	50	66	90
was	401	333	485	402	236	234	415
we	291	267	459	430	221	211	237
were	66	34	79	73	28	30	55
what	196	144	263	204	91	109	174
when	18	19	45	48	8	19	22
white	43	47	45	47	47	47	47
who	32	31	56	59	24	20	27
will	269	201	378	368	233	233	276
with	216	186	292	277	173	190	224
wont	8	10	11	17	16	11	16
worked	2	2	2	2	1	2	2
worms	1	1	1	1	1	1	1
would	13	7	13	16	6	2	7
yellow	68	68	58	70	73	72	67
you	570	473	878	786	464	440	528
youre	3	2	3	5	1	2	2
zoo	9	8	45	35	5	5	6

Appendix 4: Sample individual child reading scheme record

<u>RED LEVEL READING</u>

<u>SHEET 0</u>

<u>Ginn Little Books</u>

0 1 Shoes
0 2.Seaside
0 3.Slapstick
0 4.Birthday
0 5.Going to school
0 6.Have you seen my shoe
0 7.The Supermarket
0 8.The Star 15/9/05
0 9.Home form School
0 10.The Wedding
0 11.What shall we wear
0 12.Dora the Dragon ~~29-9-05~~
Is This My House 29.9.05

<u>First Nature Watch</u> 4/10/05 – THE PARADE

The cat
The arctic fox
The butterfly
The hamster
The hen
The polar bear
The tree

<u>ORT Stage 1-Biff and Chip Stories</u>

The swing ball
The street fair
The big box
Fetch
The hedgehog
The apple

<u>Kipper Stories</u>

At school ~~6-10-05~~
Getting up
Look out!
The haircut
The lost teddy
The library

<u>New Reading Intro Level</u>

Dad's birthday
Bad digger
Packed lunch
The toyshop
In the garden
On the beach

<u>ORT First Words</u>

Who is it 6-10-5.
Floppy Floppy 7-10-5
Six in a bed 10.10.05.
A good trick 12-10-05
Fun at the beach 14-10-05
The pancake 17-10-05

1

Ginn Pre Readers 1 – 12. LAD – 25.11.05

1. 1 Look
1. 1 Frog spell ~~[illegible]~~
1. 7 In the garden 19·10·05
1. 2 Here
1. 2 Is this my home? 20·10 05
1. 8 Baking 16 · 12 · 05
1. 3 Help 5 – 1 – 06
1. 3 Butterfly 18/10
1. 9 The parade 16 · 12 · 05
1. 4 Home
1. 4 Where is it? 2-11
1. 10 Lost 4/11/06
1. 5 Digger – 23/11/05 06/01
1. 5 Where is my bone?
1. 11 Fire ✓
1. 6 A new home – 24/11/05
1. 6 The egg 28/11
1. 12 On my bike ✓

A hard days shopping. 5/12/05
The school fair 7/12/05
The King's sock 8/12/05
The day puppy got lost
Pirate treasure 13 · 12 · 05
Where is the monster?
Look where I live
People who help us
What's in here
Living in the gardens
Animals that hide
Odd one out

Ginn Level 2.

2. 1 Liz and Digger ✓ 11/1/06
2. 1 Can we play? ✓
2. 7 The bath 13 · 1 · 06
2. 2 Can we help?
2. 2 Look like me 17 – 1 – 06
2. 8 The bee
2. 3 I can hide 20/1/06
2. 3 Up we go 17/2/06
2. 9 At night 13/2/06
2. 4 Can you? 23/1/06
2. 4 Hide and seek 6/2/06
2. 10 Where is Jill? 26 · 1 · 06
2. 5 Come for a ride 25/1/06
2. 5 Can you see me? 3 – 2 – 06
2. 11 A swim at the park ✓
2. 6 Ben and the Duck 9 – 2 – 06
2. 6 Come and play with me 10 – 2 – 06
2. 12 Come for a swim 8 3 06

Somewhere to play 2 · 2 · 06
Waiting for Tom ✓

Watch that cat ✓
The duck's day out 16 – 2 – 06
X Jill's baby brother O
You can't get me · 17 · 2 · 06
We can ride 10/3/06
Celebrations 6 · 3 · 06
Playing in the park
Fun at the swimming pool 9 · 3 · 06.
Animals at home 7 · 3
Where are you going

Oxford Reading Tree - Stage 1+

Hide and Seek – 20 – 10 – 05 } 1/2 term
Look at Me – 20/10/05
Go Away, Floppy 3/11/05
Reds and Blues 3/11/05
Big Feet ✓
Kipper's Diary 9/11/05
What dogs like ✓
Present for dad ✓
Top dog 16/11/05
Look after me ✓
Go on, Mum! 23/11/05
Go away, cat

Wrens stage 2

The headache 13/3/06
At the park 15 – 3 – 06
Fancy dress 14 · 3 · 06
Push 16 · 3 · 06
Good old Mum 18 · 3 · 06
The pet shop ✓

More Wrens

What a mess 21/3/06
Making faces 22 · 3 · 06.
The journey ✓
Goal 23 · 3 · 06
Who did that? 24 · 3 · 06
Shopping 27/3/06.

New way white

The red pig
Who are you? 28 – 3
At school 29 · 3 · 06
A picnic 30 · 3 · 06
At the shops
A birthday ✓

2

Easy Start
Lots
The book shop 05/05
Tails 04/04
I can paint 3-5-06
On the mat 05/05
Handstand 4/5/06
The Fat Fox 24-4-06
We can cook 2-5-06
Television
Birthday presents 27-4-06
The sandwich box
I can read

Parallel Books
The sand picnic 8-5-06
Come on Mum
Paint
I can 9/5/06
The shoe shop 10-5-06
Sandwiches 15-5-06

Oxford reading Tree 2
1. A new dog 16-5-06
2. What a bad dog 18/5/06
3. The go-cart 19/5/06
4. The toy's party 24/5/06
5. The dream
6. New trainers
7. Floppy's bath
8. The water fight 6/6/06
9. Kipper's balloon
10. Spots
11. The bay sitter
12. Kipper's birthday 13-6-06
13. Kipper's laces
14. The wobbly tooth
15. The foggy day 16/6/06
16. Biff's aeroplane ✓ 19.6.06
17. Floppy the hero
18. The chase 21-6-06

Oxford Reading Tree Stage 3
On the sand 22-6-06
The rope swing 23/6/06
Nobody wanted to play 27-6-06
The dolphin pool 28-6-06
By the stream 30/6/06
A cat in the tree
Strawberry Jam 5-7-06
The jumble sale 7.7.06
At the seaside 10.7.06
Kipper's idea
The snowman

3

Kipper the clown
The barbecue
The carnival
At the pool
Bull's eye 5-9-06
Book week
The cold day 19/6/07

I Back

Sparrows
Jan and the anorak
Pip at the zoo 11-9-06
Joe and the bike 8.9.06
Midge in hospital 13.9
Roy and the Budgie
Jan and the chocolate 14.9.06

RED LEVEL READING

SHEET 2

1.2.3. AND AWAY INTRODUCTORY

A Roger Red hat 15/9/06
B Billy Blue Hat 18/9/06
C Johnny and Jennifer Yellow Hat 19.9.06
D The Old Man 20-9-06
E Jennifer Yellow Hat went out in the sunshine. 22-9-06
F Jennifer Yellow Hat went out in the Dark 25 9 06
G Roger and Rip 26/9/06
H Roger and the pond 28/9/06
I Roger and Mrs Blue Hat 21-9-06
J Roger and the little Mouse 27.9.06
K Sita and Ramu 29.09.06
L Jennifer Yellow Hat went to town 2/10/06
M The Donkey went to Town 3/10/06
N Percy Green 4-10
O The little brown mouse went out in the dark. 5.10.06
P Mrs Blue Hat and the little brown muse. 6/10/06
Q Mrs Blue Hat and the red Cart. 9-10-06
R Roger, the stick and the Old Man
S Mrs Rig and the little black cat. 10 10 06
T Mrs Blue Hat and the little black cat 11.10.06
U Percy Green and Mr Red hat's car. 12.10.06
V Crash! The car hit a tree. 12.10.06
W The Kite that blew away. 13/10/06
X Ramu and Sita and the robber.
Y Jennifer and the little fox 16/10/06
Z Miranda and the dragon. 17.10.06

3 2. 3 and Away

1. The dog and the ball 6.11.06
2. The little old woman 7.11.06
3. The big dog and the little white cat. 8.11.06
4. The little old man and the donkey 9.11.06
5. Rip's bath 10 11 06
6. The old blue bus
7. Sita and the little old woman 14 11 06
8. Billy Blue Hat and the frog. 15.11.06
9. The magic wood 16-11-06
10. The witch and the donkey 17-11-06
11. The little brown mouse and the apples 20 11
12. Jennifer in dark woods 21-11
13. Percy Green and Mrs Blue Hat 22 11 06
14. Benjamin the witch and the donkey 23.11.06
15. The little old man and the little brown mouse. 24/11/06
16. Jennifer and the little dog 27.11.06
17. The Old Man and the Seven Mice 30.11.06
18. Roger has a ride 4-12-06
19. Miranda and the magic Stories 5-12-06
20. Miranda and the Flying broomstick 6.12.06

Ginn Level 3

3.1 The Park 7.12.06
3.1 The Reindeer 11-12-06
3.7 Duck trouble 12.12.06
3.2 The tortoise 13.12.06
3.3 Play a play 15-12-06
3.8 Let the dog sleep 15-12-06
3.4 I can read 10-1-07
3.2 Guess what cat found? 3 1 07
3.9 A good book 4.1.07
3.3 Horses 5.1.07
3.4 Going to the shops 8.1.07
3.10 Harold
3.5 A picnic for tortoise 9.1.07
3.6 No school today
3.11 The little rabbit
3.6 Where are you going? 12-1-07
3.6 Can I come with you? 17.1.07
3.12 The Dog House 17-1-07
The babysitter 23 1 07
Noah's Ark 22.1.07
Sparky the Dragon
Where's little Ted? 18 1 07
Dolly's magic brolly
Tom looks for a home
A duck is a duck 19.1.07
Digger at school
Don't run away
Lost and found
Work and play
Finding the key
Fast and slow
A good read 24-1-07
Grass
Babies

NEW WAY PINK (easy start)

The Fun Run
In the Pot
Kim's pet
Spots
Ring, ring
The big win

Meet the friends
Deb's book
Jip's book
Ben's book
Meg's book

4

Josh

18. Roger has a ride 4-12-06
19 Miranda and the Magic Stones 5-12-06
20 Miranda and the Flying Broomstick 6-12-06

We can ride
Celebrations
Playing in the park
Fun at the swimming pool
Animals at home
Where are you going?

Sam's book
Fat pig's book
Two folk tales
Two short stories

Parallel books
Roll over
Big Fish
Not for me
Better than you
At the fair
Lion is ill
To the moon and back
What's for dinner?

5

BLUE LEVEL READING Joshua Lacey

Red Level

New Way easy Reading (Box 1)
In the tree 5/2/07.
The Snow House 25·1·07
What can we do? 26·1·07
Sweets 29 1 07
-Yum Yum 30·1·07
-A is for Apple
-A pain in the feet
-The toy box
-The egg tree
Kim can't come 1·2·07
The bone 2.2 07
The little brown dog 6·2·07

Core Book Pat Pig's Birthday (Box 2) 8·2·07
Playtime and Sam goes to the hospital 7-2-07
Ben's bone and at the dentist ✓
Two fables
My cat and a Rainy Day 20·2·07
Super Pig and Jip the pirate 9·2·07
What a mess and the little elephant 9·2·07
The three little pigs 12-2-07
Two traditional tales 20-2-07

Parallel Books (Box 3)
My Horse can fly ✓
Adam's bike 23.2.07
A bike for five
Treasure ✓
Rats 27-2-07
Little Red Hen and the water snake 28 2 07
The Dragon's egg 1-3-07
Tigers birthday 2-3-07

Oxford Reading Tree Stage 4 (Box 4)
House for sale 5-3-07
The new house 7-3-07
Come in 6/3
The secret room 9/3/07
The Play 12/3
The Storm 9/3/07
Nobody got wet 8·3·07
The weather vane ✓
Poor old Mum 13-3-07
The Wedding 12/3
The Camcorder ✓
The Balloon 15·3·07
Wet Paint 19/3/07
Swap! 16/3/07
The Flying Elephant 19/3/07
The scarf 20/3
The dragon dance 20·3·07
Everyone got wet ✓

Sparrows (Box 5)
Roy at the Fun park 22/3
Midge and the eggs 23/3
Joe and the mouse 26/3/07
Pip and the little monkey 27/3
Lucky the goat 27/3
Adam's car 28/3
Yasmin's dress 28/3
Mosque school 29/3
Yasmin and the flood 29/3
Adam goes shopping

Oxford Reading Tree Stage 5 (Box 6)
The magic key
Pirate adventure
The dragon tree
Gran
Castle adventure
Village in the snow
The Whatsit
Underground adventure
Vanishing cream
It's not fair
The great race
A monster mistake The Sun Ship
The New baby
Camping adventure
Scarecrows
Noah's Ark adventure
A new classroom
Mum to the rescue

Ginn Level 4 (Box 7)
1. At the Zoo
1. Sam and Sue at the Zoo
7. Save the animals

(Box 8)
2. Helicopters
2. Sam and Sue at the Seaside
8. Crash landing

(Box 9)
3. A book for Kay
3. About helicopters about animals
9. The boy with the shell

(Box 10)
4. What a surprise
4. Mum's surprise ride
10. Mum's birthday surprise

(Box 11)
5. Little Monkey
5. Get that Fly
11 A special book for Jill

(Box 12)
5. Once upon a time
6. Who took my money?
11. A new boy at school

6

BLUE LEVEL READING

Level 4 Supplementary Books (Box 12)
Let's get the Tent out
The big one will eat you
The going away bag
Ben goes to School
I'm a good boy
What can we do? Green

New Way Easy Start (Box 13)
A cup of tea
The new tie
It's not fair
The secret and the Birthday Surprise
Big Head and the Greedy Dog
The Three Kings and Kim's star
Rob goes to the hospital and get well soon
The Postcard
The bad apple and the carrot field
Hello
The film star
Tim and Tom and who will push me

New Way Green (Box 14)
Bad Cow
Big Box
The camping holiday
Little Red Hen
Deb's secret wish
Red Doll
Billy Goats Gruff
The Paper Boy
Two Animal Stories

Green Parallel Books

Silly Parrot
Goodbye Little Red Hen
Come on Horse
No rain no water
Three pots of gold
The magic swan
Shoelaces
Princess Helen

1, 2, 3 AND AWAY (Box 15)
Light Green

Jook

The Village with three corners
1A The old man and the wind
1B Gopal and the little white cat
2 Billy Blue Hat and the Duckpond
2A The Cat and the feather
2B Roger and the Ghost

Dark Green (Box 16)

1 Roger and the Old School Bus
2 The Little Old Man and the Little Black Cat
3 The Old Woman and the Grandfather Clock
4 Sita climbs the wall
5 When the school door shut
6 The Big Man, the witch and the donkey
7 Caterpillars and butterflies
8 The little old man and the magic stick
9 Benjamin and the little fox
10 The cat and the witches supper

Pink Books (Box 17)

3 The Haystack
3A The donkey
3B The empty
4 The island
4A The two giants
4B The house in the corner of the wood

Red books (Box 17)

1 Jennifer and the little Black Horse
2 The old red bus
3 Billy and Percy Green
4 Roger rings the bell
5 Mr Brown's goat
6 Tom and the Monster
7 The Ghost Train
8 Sita and the Robin
9 The hole in the wall
10 The little fox

7

Appendix 5: List of words in the WPPSI language comprehension test

foot	curly tail	clenching
cup	paying	parallel
doll	till (cash register)	horizontal
giraffe	telescope	equivalent
snail	cymbals	
raining	bird beneath the tree	
butterfly	desert	
toaster	merry-go-round	
painting	balancing	
triangle	crouching	
football	posh	
lying down	shaggy	
kicking	bulldozer	
carrying	gnawing	
stirring	cylinder	
lamp	easel	
vacuum cleaner	prancing	

Appendix 6: Segmentation test

S1 Segmenting initial letter

I want you to tell me the first sound in a word I say,
so if I say soup you say ssss
and if i say mouse you'd say (pause) mmm
Good now you have a try

can
look
sing
mum
cat
light

S2 Segmenting all letters

Now I want you to tell me all the sounds in a word,
so if I say book you say b oo k
and if I say jam you say j a m
Good now you try it.

can
mum
look
cat
leg
dig
mop

S3 Segmenting CCVCs, CVCCs and CCVCCs

swim
crab
snap
plum
nest
jump
help
tent
drink
twist
stamp
plant

Appendix 7: Blending Test – script and stimuli

B1 Blending two- and three-letter words

Now I am going to say the sounds in the word and you have to guess the word.
So if I say u p you'd say up
and if I say o n you'd say on
OK now you have a try

u s
i n
m u d
b a g
t a p
m u m
b e n
t o m

B2 Blending CCVCs, CVCCs and CCVCCs

c l a p
p r a m
s t e p
p l u g
b u n k
d e s k
c a m p
m e n d
s t i n g
t r a m p
c r i s p
p l a n k

Appendix 8: Sample pages from Decoding Skills test

Word shown first alone in centre of A5 page, picture on next page after child has attempted to read word.

slug

Appendix 9: Text Test

Text Test – Passages 5 to 12

Passage 5
lets swim fast said *Jill*
like a *duck* said *Jim*
this is *fun*
I like to *splash*

Passage 6
Ben *likes going* to the *park*
Ben *likes* to *ride* on a *bike*
Ben's bike is *red* and *blue*
Jill likes to *ride* in a *car*
we all like going *fast*

Passage 7
we like to *paint pictures*
this is a *fat brown hen*
will the *fox* get it?
no the *fox* has a *sandwich* and *jelly*
I *can't* see a pig

Passage 8
Here is my dog *Teddy.*
He likes to *sniff everyone.*
My mum said "Stop him" but I *couldn't.*
We were in a *hotel.*
Teddy barked at a *lady* and her *children*.
He *climbed* in the pool and was *swimming*.
I couldn't get him to come out.
I *gave* him a *ball.*
He *wanted* to *play*

Passage 9
Billy White and A*lex Black* sat on the little *bus* going to see *Jennifer*
"There is a *brown donkey* over there" cried *Alex*.
"And a *yellow cat standing* on its back " said *Billy*.
"They are going in the little *door* with a *cross* on it.
Lets go and look. "
They got off but *left Billy's magic bag under* the *seat* on the bus.

Passage 10
Annie ran out of her house to feed her two *horses Harold* and *Ted.*
She had a *bag* with some *bread* and some *straw*
"*Guess* what we are doing this *morning*" she said.
I think *you're* going to school.
"It is *downhill* and you won't have any *trouble finding* it.
I will find the *key* and get the *cart*."

Passage 11
Granny had a garden.
Skip and *Sam* were *pet rabbits* who *lived* there. They *lived* there with the *hens* and *chicks* and a *mole*.
The *rabbits ate lettuces*. The *hens ate worms*.
Granny did not like the *mole*.
He *dug* up the *grass*.
The *rabbits* had *pink tails. They* would *roll* on the *grass* when they *heard Granny clap*.

Passage 12
Helen worked at the zoo.
She gave the food to the birds and the animals.
There were *rats* and *foxes* and a *tiger.*
There was a *tortoise,* a *mouse,* a *parrot* and a *greedy pig*.
Helen gave the *tortoise* something *green*
The *mouse,* the *parrot* and the *rats* had some *nuts*.
The *pig* had some *fish.*

Appendix 10: Word list for Text Test passages 5 to 12

item no.	word	passage in Text Test
1	duck	start 5
2	a	
3	swim	
4	Jill	
5	fast	
6	like	
7	said	
8	is	
9	this	
10	Jim	
11	let's	
12	fun	
13	splash	end 5
14	park	start 6
15	the	
16	all	
17	we	
18	bike	
19	on	
20	Ben	
21	to	
22	going	
23	likes	
24	car	
25	Ben's	
26	blue	
27	ride	
28	red	end 6

item no.	word	passage in Text Test
29	hen	start 7
30	fat	
31	paint	
32	has	
33	fox	
34	get	
35	I	
36	jelly	
37	and	
38	sandwich	
39	pig	
40	no	
41	it	
42	can’t	
43	will	
44	see	
45	brown	
46	pictures	end 7

item no.	word	passage in Text Test
47	barked	start 8
48	play	
49	wanted	
50	out	
51	ball	
52	gave	
53	were	
54	dog	
55	pool	
56	climbed	
57	children	
58	her	
59	lady	
60	at	
61	sniff	
62	hotel	
63	come	
64	but	
65	him	
66	stop	
67	Mum	
68	everyone	
69	here	
70	he	
71	Teddy	
72	my	
73	in	
74	couldn’t	
75	swimming	end 8

item no.	word	passage in Text Test
76	sat	start 9
77	bag	
78	door	
79	Billy’s	
80	left	
81	donkey	
82	cross	
83	they	
84	look	
85	black	
86	go	
87	got	
88	with	
89	magic	
90	are	
91	back	
92	Alex	
93	cat	
94	seat	
95	cried	
96	there	
97	over	
98	white	
99	its	
100	Jennifer	
101	little	
102	off	
103	bus	
104	Billy	
105	yellow	
106	standing	
107	under	end 9

item no.	word	passage in Text Test
108	feed	start 10
109	house	
110	she	
111	key	
112	Annie	
113	of	
114	finding	
115	what	
116	any	
117	have	
118	Ted	
119	you	
120	downhill	
121	two	
122	you’re	
123	think	
124	cart	
125	morning	
126	ran	
127	doing	
128	trouble	
129	guess	
130	won’t	
131	Harold	
132	horses	
133	school	
134	find	
135	bread	
136	some	
137	straw	end10

item no.	word	passage in Text Test
138	pet	start 11
139	Sam	
140	grass	
141	had	
142	up	
143	when	
144	roll	
145	would	
146	tails	
147	garden	
148	pink	
149	hens	
150	dug	
151	not	
152	did	
153	chicks	
154	clap	
155	who	
156	lettuces	
157	mole	
158	heard	
159	lived	
160	rabbits	
161	Granny	
162	skip	
163	worms	end 11

item no.	word	passage in Text Test
164	green	start 12
165	animals	
166	food	
167	parrot	
168	foxes	
169	tortoise	
170	birds	
171	fish	
172	nuts	
173	zoo	
174	something	
175	tiger	
176	was	
177	worked	
178	greedy	
179	rats	
180	Helen	
181	mouse	end 12

Appendix 11: The basis for calculating the accuracy rates for Table 5.1 used to answer research question 1

Table 5.1 from Chapter 5 is reproduced below for ease of reference.

Table 5.1: Accuracy rate for data aggregated at each level of repetitions

repetitions	accuracy rate (mean)	No. of words in sample
1	49.4%	91
2	33.7%	38
3	68.5%	28
4	**59.5%**	**28**
5	59.0%	44
6	71.4%	21
7	71.7%	29
8	77.4%	16
9	70.0%	13
10	56.0%	15
11	73.2%	26
12	79.2%	7
13	65.5%	19
14	58.3%	13
15	58.3%	8

Each accuracy rate figure shown is the mean of the accuracy rates for the children calculated individually, as can be seen in Table A11.1 shown below. Although each child was assessed on the same 181 words, their exposure to them varied as they had all read different selections of books. For example, the number of words seen by each child at a level of 4 repetitions, also shown in the same table, varied from 2 to 6. In order to give equal weighting to each child in the sample, the mean of the individual accuracy rates was entered in Table 5.1. This, however, was based on a very limited sample of words, but as the discussion in the main text pointed out, it was not just the accuracy rate for 4 repetitions that was below the criterion of 78% used to indicate reliable recognition, but the accuracy rate of the overall sample of words between 4 and 15 repetitions, which also failed to meet the criterion.

Table A11.1 Individual accuracy scores for each child for words of 4 repetitions

child id	1	7	8	16	20	21	23	mean accuracy rate
number of words	4	3	3	4	6	6	2	
number of errors	1	2	0	1	4	6	0	
Accuracy rate	75.0%	33.3%	100.0%	75.0%	33.3%	0.0%	100.0%	59.5%

Appendix 12: Design of the ANOVA used in the analyses for research questions 1 to 4 and discussion of some problems encountered

It proved difficult to find an ANOVA approach for repeated measures which accommodated two factors, one with six levels, as well as a covariate for word length, with data from just seven subjects. With the help of statistical support staff from the University of Sheffield, a model was developed with subjects as a random factor. Two of the well-known research studies described in the critical literature review, Hogaboam and Perfetti (1978) and Reitsma (1983), both made use of ANOVAs with subjects as a random factor, demonstrating its long history in psychology. It is currently popular for repeated measures designs, where it is far more flexible than the standard repeated measure approach available in SPSS. This was the main reason for its use in the current analysis.

In addition, to make maximum use of the small dataset consequent on the limited number of subjects, an aggregation was created which used four break variables (decodability, frequency bands, word class, and child). This produced 143 observations for the seven children. If the minimum aggregation had been used (e.g. for a two-factor analysis, it would only have produced 84 observations – frequency bands 6 levels X decodability 2 levels X 7 children = 84). The four-way aggregation thus almost doubled the number of data points and made the analysis more sensitive.

There is not always an entry at every level for each factor, resulting in some ‘missing’ observations. If all factors had appeared at every level of repetition one would expect 168 observations overall (i.e. 7 children X 24 observations – 2x6x2). There were only 143, i.e. 25 missing, resulting in between18 and 22 observations per child. This proved sufficient for the analysis, and was far more sensitive than the minimum aggregation possible. This aggregation was used for the ANOVA analyses for research questions 1 to 3. Research question 4 required a slight variation with morphemic complexity substituted for word class.

It is suggested that when using such aggregations the majority of rows generated in the aggregation contain 5 or more observations. This was true for over 60% of the rows, which the statisticians responsible for the design of the model stated was in line with accepted practice, and adequate for the analysis.

It must be said that only the minimum aggregation for the one-factor ANOVA for frequency bands with 42 observations (7 children X 6 levels of repetition) had a normal distribution. The three minimum aggregations for the two-factor ANOVAs for decodability, word class and morphemic complexity, all with 84 observations (i.e. 7 children X 6 frequency bands X 2 levels of the other factor) were not normally distributed. This remained true after a variety of transformations (i.e. log, square root and inverse). The aggregations eventually used had the same problem, but ANOVA is felt to be relatively robust, and the predicted problem when normality of predictors is not met is a loss of power in finding significant effects (Wilcox 1995). This did not prove to be a problem, as in all analyses some factors were significant.

To avoid misleading results due to distortions in the data, it is essential that residuals in the model are normally distributed (Field 2005, Rutherford 2000).

Tests indicated that this condition was met for all ANOVAs carried out, applying to both deleted and studentised residuals.

Problems were encountered with Levene's homogeneity of variance test proving significant or almost significant for two of the ANOVAs (Decodabilility p=0.049; Frequency bands, one factor p=0.056). This problem, according to Pallant (2013 p.279), requires a more stringent alpha level to be used, suggesting that, rather than using a significance level of p=0.05, "… it is recommended that you set a more stringent significance level (e.g. 0.01) for evaluating the results of your two way anova."

In the two ANOVAs where Levene's test was significant or approached significance, the factors tested in the model showed very high levels of significance equalling 0.001 or less than 0.001, substantially better than the normally acceptable level of 0.05 and in line with Pallant's recommendation. This has been reported in chapter 5.

To double check ANOVA results thoroughly, analyses were run using logistic regression which is much less exacting and does not require normally distributed data. This is not included in the dissertation analysis but has been provided in appendix 14. The identical factors used in the ANOVAs were entered as predictors together with the covariate. The same general pattern of results was obtained.

Appendix 13: Logistic regression with four function word outliers removed

Table A13.1 below shows the regression coefficients, Wald tests and odds ratios for the predictors, once the four function words which were extreme outliers shown in Table A13.2 were removed. As with the logistic regression with outliers in, reported in the dissertation for research question 5, predictors were entered in a single step.

Table A13.1: Logistic regression predicting word recognition from level of repetition, decodability, word length in letters, morphemic complexity and word class

Predictor	B	S.E.	Wald	*p*	odds ratio
repetitions	0.025	0.003	57.047	<0.001	1.025
decodability	1.280	0.244	27.602	<0.001	3.596
word length	-0.264	0.064	17.202	<0.001	0.768
morphemic complexity	0.126	0.177	0.511	0.475	1.135
word class	0.097	0.243	0.159	0.690	1.102
Constant	1.254	0.405	9.594	0.002	3.506

Table A13.2: Function words which have been removed

word	repetitions	Child ID	Z resid	word class
he	339	21	-34.43	function
no	167	21	-7.36	function
of	138	20	-10.90	function
they	344	16	-28.317	function

Appendix 14: Logistic regression double check – Re-run of research questions originally analysed with ANOVAs

The Tables below show logistic regression results for the same factors as those entered in the ANOVAs used to answer research questions 1 to 4.

These produced significant and non-significant results which were in line with the ANOVAs, and hence demonstrated that the lack of normal distribution of the data used had not overly distorted the results reported in the main text.

Research question 1: All words together

Factors – frequency bands and word length

Frequency band significant $p<0.001$
Word length significant $p <0.001$

Table A14.1 frequency bands and word length

predictors	B	S.E.	Wald	Sig.	odds ratio
wordlength	-0.4108	0.054	57.404	<0.001	0.665
frequency	0.562	0.052	116.785	<0.001	1.755
Constant	1.403	0.335	17.542	<0.001	4.0766

Research question 2: Decodable versus non-decodable

Factors – frequency, decodability and word length.

Frequency band significant $p<0.001$
Decodability significant $p<0.001$
Word length significant $p <0.001$

Table A14.2 frequency bands, decodability and word length

predictors	B	S.E.	Wald	*p*	odds ratio
wordlength	-0.280	0.058	23.363	<0.001.	0.7656
frequency	0.561	0.052	114.795	<0.001	1.752
decode	1.2326	0.237	26.661	<0.001	3.4108
Constant	0.521	0.371	1.9767	0.161	1.683

Research question 3: Content versus function words

Factors- frequency, word class and word length

Frequency band significant $p<0.001$
Word class non-significant $p=0.60$
Word length significant $p<0.001$

Table A14.3 frequency bands, word class and word length

predictors	B	S.E.	Wald	*p*	odds ratio
wordlength	-0.410	0.054	57.7326	<0.001	0.663
frequency	0.570	0.054	110.5548	<0.001	1.769
Wordclass	-0.120	0.2328	0.2879	0.60597	0.887
Constant	1.413	0.335	17.735	<0.001	4.106

Research question 4: Mono- versus multi-morphemic words

Factors – frequency, morphemic complexity and word length

Frequency band significant $p<0.001$
Morphemic complexity non-significant $p=0.79$
Word length significant $p<0.001$

Table A14.4 frequency bands, morphemic complexity and word length

predictors	B	S.E.	Wald	*p*	odds ratio
wordlength	-0.413	0.057	52.801	<0.001	0.662
frequency	0.565	0.053	114.453	<0.001	1.7659
morphcomp	-0.0546	0.172	0.073	0.7987	0.955
Constant	1.4547	0.374	15.009	0.000	4.251

Appendix 15: Guide to the data disk

The data disk contains a spreadsheet and SPSS files showing raw and aggregated data together with the analyses reported in the thesis and a sample of the syntax used, together with a WORD file which provides the index.

The spreadsheets on the data disk were used to produce the bar charts shown in chapter 5.

You will need a copy of Excel 2000 to open the spreadsheet, and SPSS to open the statistical files.