# Phonological and Semantic Factors in Children's Acquisition of a Sight Vocabulary in Reading

Emma Claire Laing

A thesis submitted for the degree of Doctor of Philosophy.

University of York, Department of Psychology.

# Abstract

Some models of reading development have suggested that children initially learn to read using a whole word or 'logographic' strategy. According to such models it is the visual rather than the phonological features of a word which will determine the ease with which beginning readers will learn to read it. The studies presented here explore the factors which influence the ability of young children to learn to read single words and provide evidence that beginning readers are influenced by phonological and semantic factors

The relationship between children's implicit use of phonology in reading and their ability to reflect upon phonology explicitly, in phonological awareness tasks, is examined in this thesis. It is shown that both the phonological quality of the words themselves and the phonological skills of the children influence the ease with which they can learn to read words. Firstly, abbreviated words (cues) which are phonetically similar to their spoken counterparts were learnt more easily than cues which were phonetically less similar. This was found to be the case even for children in the very early stages of reading development who were not yet able to decode even very simple words. Secondly, children's learning was predicted by their phonological skill, in particular by their phonemic awareness. These findings suggest that even children in the initial stages of reading development are able to access and use phonological information when learning to read words.

The influence of semantic factors was also considered. It was found that children's ability to learn to read words was strongly related to their knowledge of the words' meanings. Although most models of early reading development have focused on the importance of phonological skills, the results presented here suggest that semantic skills are also important in early reading development. A series of experiments are presented in which the influence of the semantic variable, imageability, is considered. It was found that beginning readers learn to read high imageability words more easily than low imageability words, even when familiarity, age-of-acquisition and grammatical class is controlled for. A final concern of this thesis is the possible interaction between these phonological and semantic influences. The results presented here would seem to indicate that phonological and semantic factors make separate contributions to reading development, at this stage. However, it was found that good and poor beginning readers were differentially affected by the phonological and semantic qualities of the words they learnt. Good beginning readers were more influenced by the phonological qualities of the words, and the poor beginning readers were more influenced by the semantic quality of the words. It is argued that the results of these experiments are best accommodated within a connectionist model of reading development.

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# Summary

Some models of reading development have assumed that children initially learn to read words using a whole word or 'logographic' strategy and are influenced by salient visual features. However, some evidence has also suggested that children are able to use phonology from the very earliest stages of development. According to this view children do not have to await an alphabetic stage in which they are able to systematically decode words, children will implicitly use partial letter knowledge to form connections between print and its spoken form as soon as they begin to learn to read. The relationship between this implicit use of phonology and a meta-cognitive awareness of phonology is examined in this thesis. More specifically, questions are asked concerning the nature and extent of children's ability to use phonological information at the very start of reading development. A second issue considered is the role of semantic factors in early reading development. Many models have focused primarily on the importance of phonology, arguing that semantics does not play a part in reading development until a later stage. However, it is also possible that semantic factors have a part to play in early reading development. Finally the possible interaction between phonological and semantic factors in reading development is considered.

Chapter 1 presents a detailed review of the relevant literature. As well as discussing models of reading development, the review also considers the evidence linking phonological awareness skills to reading. As suggested above some models of reading development have suggested that children at a very early stage of reading development read words use a 'logographic' strategy. However, this chapter also reviews research which suggests that children may be able to access and use phonological information from the outset of learning to read. This research suggests that children are able to access much smaller units of phonology when learning to read, than they are consciously aware of, as suggested by their performance in phonological awareness tasks. The need to draw a distinction between children's implicit access to underlying phonological representations and their meta-cognitive phonological awareness is discussed. It is suggested that children are able to use partial letter knowledge to form direct connections between print and its spoken form. Although most models of reading development focus on the role of phonological skills, there is also some evidence to suggest that semantic skills play an important part in learning to read, this evidence is discussed in this chapter. It is suggested that the role of semantic factors in early reading development may previously have been underestimated, furthermore, little is known about the ways in

which phonological and semantic factors may interact with each other in this very early stage of development.

Experiment 1 investigates the ability of 4, 5 and 6-year-old children to learn to associate three letter abbreviated cues with spoken words. Two types of cue are created, phonetic cues, in which the central letter in the cue is phonetically similar to the central phoneme in the target word, and control cues, in which the central phoneme is phonetically dissimilar from the target word. It is found that all three age groups learn the phonetic cues more easily than the control cues, suggesting that even children at the very early stages of reading development are sensitive to the phonological information in words they learn. Furthermore, their ability to learn the cues is shown to be strongly related to their performance in phonological awareness tasks, in particular their phonemic awareness. It is also the case that their ability to learn to read the cues is influenced by their knowledge of the meaning of the words, suggesting that their semantic knowledge is also an important influence.

Experiment 2 considers the influence of both phonological and semantic factors in a word learning task. Five- and six-year-old children are taught to read a series of words which differ in their regularity and their imageability. While the children are strongly influenced by the rated imageability of the words they are learning they do not show a difference in their learning of regular and irregular words. It is suggested that one possible reason why regularity does not influence these children is the definition of regularity used. The ability to learn to read the words is again shown to be related to measures of phonological and semantic skill. Experiment 3 investigates the role of imageability further by controlling for grammatical class as well as familiarity, and age-of-acquisition. Children's learning is again shown to be strongly influenced by imageability, they learn high imageability words more easily than low imageability words. Experiment 3 confirms that this influence of imageability is not the result of a bias towards words of a certain grammatical class.

Experiments 4 and 5 investigate the influence of regularity. In these experiments care is taken to ensure that the irregularity in the words is found in the consonants. It is argued that because children's representation of vowels is inconsistent at this age they are less likely to be affected by irregular vowels than they are by irregular consonants. It is found that when children are taught words with irregular consonants and words with regular consonants they find the regular words much easier to learn to read. It is important to note that this is the case even for children at this very early stage of reading development, who are not yet able to decode even simple words. As in previous experiments learning is related to measures of phonological and semantic skill. Tasks based on the actual words to be learnt are not found to be stronger predictors of learning than tasks based on words not learnt.

The possible interaction between phonology and semantics is considered in Experiments 6 and 7. In Experiment 6, 5-year-olds were taught to associate three letter cues with target words, as in Experiment 1. The target words in Experiment 6 also differ in their imageability. It was predicted that if phonological and semantic factors interact in early word learning then control cues would show a stronger imageability effect than the phonetic cues. That is, when orthographic-phonologic translation is most difficult, semantic factors would be more likely to play a role. This is not found to be the case. The children's ability to learn the cues is influenced by both their phonetic quality and by their imageability, but no interaction is seen between these factors. However, when good and poor beginning readers are given a similar task in Experiment 7 an interaction is seen. The good and poor readers are differentially affected by the phonological and semantic quality of the words they are learning. The good readers show a stronger phonetic cue effect than the poor readers, who in turn, are more influenced by imageability than the good readers. It would seem that the poor phonological skills of the poor reader group leads to a greater reliance on the semantic quality of words.

The implications of this research are discussed in Chapter 7. It is concluded that young children are able to access and use phonological information from the earliest stages of reading development. This early use of phonology is not a systematic use of letter-sound knowledge, but the use of some letter information to aid in the formation of partial connections between print and its spoken form. This implicit use of phonology is found to be strongly related to the explicit use of phonology in phonological awareness tasks. It is argued that these findings can best be explained within a connectionist model of reading development. In such a model learning to read involves the learning of associations between sound and print implicitly and does not rely on the use of systematic rules or on the acquisition of an alphabetic strategy. The finding that the semantic quality of words also influences the ease with which beginning readers learn to read them challenges the notion that semantics is less important than phonology at this very early stage of reading development. It is argued that the role of semantics may also be interpreted within a connectionist framework in which the activation of semantic and phonological features may happen almost simultaneously. Finally, some suggestions for future research and the implications of this research for educational practice are discussed.

# Chapter One

# Introduction and Literature Review

## 1.1 Introduction

Amid great concern about standards of literacy in Britain's classrooms the government has designated 1998 the 'National Year of Reading'. Never before has there been such interest in how children learn to read and in which teaching methods are the most successful. Learning to read and write are clearly tasks of key educational importance. Literacy underpins the entire education system and the failure to develop these skills will have a profound impact on a child's education.

Decades of research have resulted in a reasonably consistent picture of how reading develops and how it is best taught. There has been an increasing understanding of the processes that underlie learning to read and in the factors that influence the reading success of young children. Firstly, there is a large body of research linking phonological awareness, i.e. the ability to reflect upon and manipulate speech sounds, to reading development. Secondly, there is evidence that another factor that influences children's reading is not so much the explicit awareness of phonology but the way in which phonology itself is represented. It is suggested by some that it is the quality of the underlying phonological representations which is tapped in phonological awareness, memory and speech rate tasks, all of which have been shown to be related to reading. Finally, although many models of reading development have emphasised the central role of phonological skills in learning to read, there is also some evidence to suggest that semantic factors may play a role.

In spite of these advances, relatively little is understood about how these factors interact with each other, particularly in the very early stages of reading development. Furthermore, although many models of reading development have been proposed, most are limited in their ability to explain the mechanisms by which phonological and semantic factors are related to reading development. This chapter reviews the evidence linking phonological and semantic factors to learning to read and considers how the role of these factors in reading development have been understood within models of reading development.

## 1.2. The Relationship between Phonological Skills and Learning to Read

### 1.2.1. Introduction

The relationship between phonological awareness skills and reading success is now well established. Phonological awareness refers to the ability to reflect upon, and manipulate, the sounds of speech. Numerous studies, using differing methodologies, have shown a relationship between the two variables.

### 1.2.2. Simultaneous Correlational Studies

There are a large number of studies which show that there is a strong correlation between measures of phonological awareness and measures of reading attainment. The studies reviewed in this section are based on correlations between measures of phonological skills and reading taken at the same point in time.

Rosner & Simon (1971) studied the performance of 284 children, from kindergarten to Grade 6 on a number of phoneme deletion tasks. In each task the child was required to repeat the word after the experimenter deleting certain specified phonemic elements, from the beginning, end and medial positions. The children's performance on this phoneme deletion task and a measure of their reading ability was found to correlate strongly and the strength of this correlation increased with age. The correlations ranged from .53 in Grade 1 to .84 in grades 1-3 . These correlations were still found once IQ had been controlled for, partial correlations indicated that the phonemic measure accounted for 16%, 38% and 48% of variance in reading performance in grades one to three respectively. Similarly, Kirtley, Bryant, MacLean & Bradley (1989) found a strong relationship between tasks in which children had to categorise words according to various criteria in an oddity task. In this study 64 children with a mean age of 5.7 had to decide which word was the odd one out by virtue of it not sharing the same beginning or ending. A particularly strong connection was found between reading and performance in a task in which children had to categorise words either by their final consonant or by their final consonant and a vowel.

Tunmer & Nesdale (1985) found that phoneme segmentation in non digraph words ( i.e. words without digraphs such as 'ee' and 'oo') was related strongly to reading even after IQ had been controlled for. The task required the child to count and tap the number of phonemes in a word. A multiple regression analysis showed that non digraph word segmentation accounted for 21% ($p<.001$) of the variance in reading performance after differences in verbal IQ had been accounted for.

The fact that all of these studies controlled for IQ is clearly an important fact. Had IQ not been controlled for it would have been possible to argue that performance on both reading and phonological awareness tests is attributable to a third variable, general intelligence. It is, therefore, important to establish that phonological awareness still correlates strongly with reading even after measures of IQ have been controlled for. The above studies, in doing this, suggest that the relationship between reading and phonology is largely independent from IQ.

### 1.2.3. Longitudinal Correlational Studies

Longitudinal studies involve obtaining measures of phonological awareness and reading at various points in time. Studies of this type allow much firmer conclusions to be made about the causal and predictive nature of the relationship between phonological awareness and reading development. A large number of such studies point to a relationship between phonological awareness and learning to read (Bradley & Bryant 1985; Bryant et al. 1990; Lundberg et al. 1988; Stanovich, Cunningham & Cramer 1984; Wagner & Torgeson 1987, 1994; Muter, Hulme, Snowling & Taylor, 1997). Measures of phonological awareness have been shown to be stronger predictors of reading than intelligence, vocabulary and listening comprehension.

Stanovich, Cunningham & Cramer (1984) gave 49 six-year-old kindergarten children 10 phonological awareness tasks and a year later assessed their performance in reading. The phonological tasks were three tasks measuring rhyme and seven measuring phoneme awareness. The phoneme awareness measures were found to correlate significantly with reading performance, the coefficients ranging from .39 to .60. Wagner & Torgeson (1987) re-analysed their results controlling for IQ and found that the pattern of results was little altered, the phoneme tasks remained significantly correlated with reading ( the partial correlation coefficients ranged form .08 to .58, with a median of .35). A year later Stanovich looked at the children still in the study (N=31) and divided them into two groups, good and poor readers. He found a significant difference between the performance of the two groups on measures of phoneme awareness and rhyme detection. Regression analyses suggested that these two phonological tasks taken together predicted 66% of the variance in reading. However, it should be noted that neither IQ nor differences in the children's reading skill were controlled for in this regression analysis.

Mann (1984) gave 44 kindergarten children a syllable awareness task in which they were required to reverse syllables in two-and three-syllable words and a phoneme awareness task that required reversing the order of phonemes in a two phoneme nonsense word. They were also given an IQ test. A year later a number of reading tests were given to the children. The relationship between phoneme reversal and reading was strong ($r = .75$, $p < .001$), however, no relationship was found between syllable reversal and reading. The partial correlation holding IQ constant was identical. This study establishes a clear relationship between phonological awareness and reading, however, because the children's reading at the start of the study was not measured, it remains a possibility that pre-existing individual differences in reading at the start of the study could account for part of the relationship.

Bradley & Bryant (1985) undertook a three year study in which they looked at the development of 368 children. The children were all non-readers at the start of the study and were all aged between 4 and 5 years old. Phonological awareness was measured with a sound categorisation task, which required the children to identify the odd word out from a set of 3 spoken words. The children were also given a memory task in which they were required to repeat the list of words without identifying the odd one out. Three years later the children were given two standardised reading tests, a spelling test, a maths test and a short form of the WISC (1974). The sound categorisation score was significantly correlated with the reading performance three years later, with correlations of .52 and .57 for the two reading tests respectively. Holding age at initial test, IQ and memory constant they found that sound categorisation accounted for 10% of the variance in reading. The influence of the sound categorisation task was limited only to reading and spelling, it did not account for significant variance in maths scores.

Lundberg, Olofsson, and Wall (1980) included a range of measures of phonological awareness in their study: segmenting and blending of syllables and phonemes, determining the position of a target phoneme, reversing phonemes and rhyme. The children were tested as pre-readers at age 7 on the phonological awareness measures, and one year later were given tests of IQ, reading and spelling. All the measures of phonological awareness correlated significantly with subsequent reading performance. The strongest correlation was with phoneme reversal, ($r = .55$,

$p<.001$) which was more strongly related to reading than syllable segmentation ($r=.13$, $p<.04$).

The Lundberg et al. data was re-analysed by Wagner & Torgeson (1987) in order to examine the effect of controlling for pre-existing reading skills and IQ. Partial correlations holding IQ constant ranged from $r=.09$ ($p<.05$) for syllable segmentation with concrete materials, to $r=.53$ ($p<.001$) for phoneme reversal. This shows that phonological awareness in kindergarten is related to reading performance in Grade 1 independently of IQ. They also used path analysis to look at the possible effects of pre-existing levels of reading skill on the relationship between phonological awareness and later reading. Was it possible that part of this relationship could be attributable to children's reading skills before the study began ? Partial correlation coefficients were calculated holding the score on the kindergarten reading test constant. Only two of the partial correlations were found to be significant (phoneme reversal and phoneme synthesis) suggesting that individual differences in reading ability at the start of the study could account for at least part of the relationship. Nevertheless, it is still clear that some measures of phonological awareness remains predictive of subsequent reading even with IQ and pre-existing reading controlled for

A number of things can be concluded from these studies. Firstly, these simultaneous and longitudinal correlational studies establish that there is a strong relationship between measures of phonological awareness and reading achievement. However, questions about the causal nature of this relationship remain. A large number of the longitudinal studies to date have not controlled for reading performance at the start of testing leaving them open to the possibility that initial differences in reading skill may account for the relationship between phonology and reading. Questions need to be asked about the development of phonology and the extent to which this is influenced by early reading experience. The results from these studies raise the possibility that some aspects of phonological awareness have a stronger relationship with reading than others, for example, there is some evidence that phoneme measures correlate more strongly with reading than measures of syllable or rhyme awareness.

### 1.2.4. The Reciprocal Relationship

Although a clear association between phonological awareness and reading performance has been demonstrated and well replicated, the nature of the relationship between the two is less clear. A number of causal relationships are possible. Firstly, it could be that good phonological skills lead to good reading development.

Secondly, it could be that the converse relationship is true, that reading development causes phonological awareness. Thirdly, it is possible that phonology and reading are both dependent on a third factor, for example, maturity or general intelligence. Finally, a reciprocal relationship between reading and phonological awareness might exist. It could be that the child's early awareness of the phonology of their spoken language facilitates learning to read and that learning to read in turn facilitates the subsequent development of some kinds of phonological awareness.

In order to examine this issue of causality Morais, Cary, Alegria & Bertelson (1979) looked at the performance of Portuguese adults on a number of phonological awareness tasks. Half of the subjects were illiterate and half were able to read. Performance on all of the tests was significantly worse for the illiterate group. On deletion tasks the illiterate group succeeded in 26% of tasks with words and 19% with nonwords, the literate group scored 87% and 73% respectively. In tasks requiring subjects to add on sounds the illiterate group scored 46% and 19% with words and nonwords, and the literate group scored 91% and 71%. The authors concluded that phonological awareness arises as a consequence of learning to read and not the other way around. However, the fact that even the illiterate adults could do the tasks to a certain extent suggests that some degree of phonological awareness skill is possible without learning to read.

It is likely that reading ability and phonological awareness are interdependent during development, and that a reciprocal relationship exists between them. Perfetti, Beck, Bell & Hughes (1987) gave tests of phoneme blending, phoneme deletion and nonword reading to eighty two six-and seven-year-old children over the course of Grade One. The children were put into two groups according to the reading instruction they were receiving. One group were taught by a phonics programme that included letter-sound correspondences and blending (the direct code group), the second group learnt using a basal reading scheme with less phonics instruction (basal). They used cross-lagged correlations to investigate how phonological awareness and nonword reading were interrelated. The principle of cross-lagged correlations is that if variable x causes changes in variable y and not the other way round, then the correlation of x at time 1 with y at time 2 should be larger than that between y at time 1 with x at time 2. The results of the analysis suggested a reciprocal relationship between reading and phonological measures. For both groups performance on the phoneme synthesis task predicted later reading, however, nonword reading went on to predict performance on the phoneme deletion task. Although these results provide some evidence for the reciprocal causality hypothesis they are problematic because of the statistical method used, which has been severely criticised (Rogosa, 1980).

Goswami & Bryant (1990) also suggest a reciprocal model. They argue that awareness of the onset-rime division is the crucial factor in the early stages of learning to read and that awareness of phonemes arises as a consequence of learning to read. The terms 'onset' and 'rime' refer to parts of a syllable; the onset is the initial consonant or consonant cluster in a syllable and the rime is the vowel and succeeding consonants in the syllable, so, for example, in a one syllable word like CAT, /k/ is the onset and /at/ is the rime. The development of onset/rime awareness will be considered further in Section 1.4.1. One task that taps children's awareness of rime is rhyme detection. It has already been shown that rhyme detection can be performed by prereaders and that rhyme detection can successfully predict later reading achievement (Bradley & Bryant 1983). However, the way in which this awareness of rhyme influences reading is less certain. Goswami (1986) taught children to read words and nonsense words that were analogous to 'clue' words. Children learnt words more easily if they shared a rime with the target word than in words that just shared some common letters. She argues that it is sensitivity to rhyme that aids beginning reading in recognising common spelling patterns in different words. Goswami (1993) argues that the use of vowel analogies develops as reading develops. Beginning readers who, according to Goswami, are most aware at the onset-rime level use the word 'bug' to read the word 'rug' but not to read 'bud' (which shares the onset-vowel) or 'cup' which shares a phoneme. Older children, it was found, could use 'beak' to help them read 'mean' and 'heap' as well as 'peak'. Goswami argues that phonological knowledge and orthographic knowledge influence each other during development. That is, children begin to analyse orthography with the phonological skills first available to them (onset-rime skills) and that developing orthographic knowledge then influences phonological awareness.

However, a number of criticisms have been made of this model of reading development. Ehri & Robbins (1992) argue that beginning readers need some decoding skill before they can begin to use analogy. They studied forty-five decoders and forty-three non decoders. They found that the non-decoders were not any more successful in reading transfer words than control words, however the decoders learned significantly more transfer words than control words ($p<.01$). It is argued that these decoding skills are needed in order to learn novel words on the basis of analogy to others.

The second part of the Goswami & Bryant argument is that rhyme makes a contribution to reading which is independent of any contribution from phonemic skills. Bryant, MacLean, Bradley & Crossland (1990) studied sixty four children with a mean age of 4 years 7 months over a period of two years. The children were given tests of rhyme and alliteration and were later given tests of phoneme deletion and tapping. They found that rhyme made an independent contribution to reading development via phoneme awareness, but also that the rhyme and alliteration measure accounted for unique variance in reading performance even after phoneme segmentation was controlled for (7%). These findings lend support both to the notion that the influence of rhyme is mediated by phoneme awareness and to the argument that rhyme exerts a direct influence on reading. Bryant et al. argue for a double influence of rhyme.

The Bryant et al. study has been criticised on a number of grounds. Firstly, measures of children's reading were not taken at the same time as the phoneme segmentation measures and therefore it is not clear whether prior phoneme segmentation ability (which might itself be a product of their reading skill) was confounded with reading, and whether it was this that turned out to be predictive of later reading. Similarly, the rhyme and alliteration measure at time two predicts performance on the other phonological awareness tasks at time three, which in turn predicts reading at time three. However, children's progress in reading by time two was not measured and hence could have been a common factor influencing both sets of scores. Furthermore, because the tests of phoneme segmentation and rhyme were not given at the same time it is impossible to say whether phoneme deletion at a certain age might have been more predictive of reading than was rhyme at the same age. Finally, the decision to combine rhyme and alliteration into one measure has been questioned (Rack et al. 1993). Using a composite measure makes it hard to establish that it is rhyme awareness that predicts phoneme awareness and reading. It would seem that establishing causality from this study is problematic and although it seems possible that rhyme does exert an influence on reading as Bryant et al. suggest, the exact causal role of rhyme is still uncertain.

Muter, Hulme, Snowling and Taylor (1997) studied the development of phonological awareness in thirty eight four-year-old children over a two year period. The children were given four phonological awareness tasks in the nursery, a rhyme detection task, a rhyme production task, a test of phoneme segmentation and a phoneme deletion test. These tests were repeated in the children's first and second year at school, along with a sound blending task which required the child to join together a string of phonemes provided by the examiner. The results were contrary to what Goswami and Bryant's theory would predict. It was phoneme segmentation and not rhyming skill that predicted both reading and spelling at five and six years old. Children's existing reading vocabulary was also a powerful predictor of their reading by the second year at infant school. Muter, Snowling and Taylor (1994) also looked at the relationship of these skills to use of analogies. They found that the analogy effect was strongly correlated with reading performance and that the use of analogies at six was predicted by concurrent measures of both rhyme and segmentation, but not by pre-school rhyming skill. It seems quite possible that children first need some awareness of letter-sound correspondences before they begin to use analogies (Ehri & Robbins 1992).

In summary, there seems to be evidence of a causal relationship between phonological processing skills and learning to read. However, this does not rule out the possibility that some phonological awareness skills are themselves influenced by learning to read. This notion of reciprocal causality will be referred to again in the section on models of reading development.

### 1.2.5. Intervention Studies

A further way to examine the causal nature of the relationship between phonological awareness and reading is to consider studies which have attempted to train children's phonological skills to investigate whether this leads to a subsequent improvement in reading. If improving phonological skills can be shown to improve reading then this provides good evidence that a causal relationship exists.

#### 1.2.5.1. Phonological Awareness Training

A large number of studies have shown that phonological training can improve reading (Fox & Routh, 1976; Bradley & Bryant, 1983; Treiman & Baron, 1983; Cunningham, 1990; Ball & Blanchman, 1991; Lie, 1991; Iversen & Tunmer, 1993; Hatcher, Hulme & Ellis, 1994). Fox & Routh (1976) looked at the effects of training children to blend phonemes on a paired-associate reading analogue task in which they trained 40 four-year-old children to associate sounds with letter-like strings. Half of the children were given training in sound blending. They found that the training improved their performance in the learning task but only if the children were already able to segment words. They concluded that phonemic analysis (segmentation) and synthesis (blending) are both important for children's word attack skills. However, there are a number of problems with the study. Firstly, the data was based on non-words rather than words and similar effects would need to be shown using words. Secondly, the training by segmentation interaction may have been due to a floor effect for the children who could not segment.

Lie (1991) looked at the effects of phoneme isolation and segmentation training on the reading and spelling of seven-year-old children. Two hundred and eight children were observed from the beginning of grade one to the end of grade two. Three conditions were included in the study: (1) children were taught to attend to individual phonemes in the initial, medial and final position in words; (2) children were taught to identify phonemes in a word in the correct sequence and to blend them; (3) as a control children looked at pictures and discussed them. The children received daily sessions of 10-15 minutes for one term. The groups did not differ in IQ, auditory linguistic ability or letter writing scores at the outset. The sequential analysis training (group 2) was found to have the most influence on subsequent tests of reading performance. By the end of Grade One only the sequential group was significantly different from the control group ($p<.05$) on tests of reading, they were still performing better at the end of Grade Two but only marginally ($p<.10$). A significant main effect of intelligence was found, ($p<.01$), and there was a significant intelligence by group interaction, ($p<.05$). This suggests that the effect of training was greatest for the lowest in intelligence. This study again shows the effect of phonological awareness training on reading and spelling, the phoneme identification training and the sequence training had positive effects on spelling, while the phoneme sequence training seemed to have a shorter term effect on reading. These results are supportive of a causal relationship between segmentation skills and learning to read. However, there are a number of problems with this study. Reading and spelling ability at the start of the study was not measured and so it is not clear if pre-existing skills may have had an influence. Furthermore, it is not certain that the benefits of the programme are specific to reading because no measure of an unrelated skill was included.

Lundberg, Frost & Petersen (1988) did include a measure of maths ability and hence their results are more convincing in showing a specific benefit of phonological awareness training. Lundberg et al. used a programme of phonological training (rhyme, syllable segmentation, syllable synthesis, phoneme segmentation and phoneme blending) with 235 kindergarten children over eight months and looked at the long-term effects on reading and spelling. Half the children received training and half formed a control group who did not receive any form of intervention. They found that the experimental group performed significantly better than the control group on a total combined score of phonological awareness, ($p<.0001$). In terms of reading, analysis of variance showed a strong main effect of grade ($p<.0001$), and a significant effect of group ($p<.05$), as well as a significant grade by group interaction ($p<.05$). This suggested that the effect of the training was even stronger at Grade 2. Indeed, there was no significant interaction between the two groups in Grade 1, but the experimental group performed significantly better in Grade 2. Improving phonological awareness skills was shown to have an effect on reading and spelling but not on maths.

The effects of the training differed for different aspects of phonological awareness. Although statistically significant, the effects of training on rhyming and syllable awareness were comparatively modest, whereas the effects of training on phonemic tasks were much stronger. The experimental group still outperformed the control group on measures of single word identification and a sentence reading test at the end of Grade 3 (Lundberg & Hoien 1991). Furthermore, a sub-analysis showed that pre-school training of phonological awareness had the effect of bringing the worst readers in the experimental group to the same level as the children who had received no intervention whereas the poorest readers in the control group fell further behind. Lundberg and Hoien argue that pre-school training of phonological skills can prevent reading failure in school.

The results are impressive in showing that phonological skills can be improved, which in turn improves reading, such a pattern suggests a causal relationship between phonological awareness and reading. However, it must be noted that the long term difference between the groups was only marginally significant, particularly given the amount of intervention the children received (Lie 1991; Rack, Snowling & Hulme 1993). One possible criticism of the study is that the control group did not receive any intervention making it arguable that the improvements were the results of additional attention per se rather than the content of the programme. However, the specificity of the effect makes this unlikely.

#### 1.2.5.2. Linking Phonological Awareness to Reading Instruction

Bradley & Bryant's (1985) study suggests that when phonological training is integrated with reading and spelling it is more effective than when training in phonological skills is given alone. Sixty-five six-year-old children were selected on the basis of performance on a sound categorisation task, IQ, sex and age. The children were split into four groups. One group received sound categorisation training, teaching children to categorise words on the basis of their sounds. A second group received the same training as the first group but in addition used plastic letters to manipulate sound patterns in words. A further group got the same amount of training as the experimental groups but were trained to categorise words based on conceptual categories rather than sound. The final group received no training at all. The children were taught once a week over a two year period. It was found that the training which used sound categorisation training with letters was the most effective for improving children's reading. This training raised the children's reading ages by an average of 9 months ($p<.05$) and the spelling ages by 17 months ($p<.01$) compared to the conceptual training. These results were specific to reading and spelling and the groups did not perform differently in maths ($p>.05$). The most effective training programme involved children making a connection between sounds in words and their spelling pattern. These results suggest that combining phonological training with a phonics based reading approach might be the most effective.

Cunningham (1990) gave kindergarten and first grade children two forms of phonological awareness training and examined which was the most effective. The children received either a 'skill and drill' approach where they were taught to segment and blend words, or a 'metalevel' approach where children were taught blending and segmenting skills but were also taught explicitly how to relate this to their reading. A control group listened to stories and answered questions about the stories. The experimental groups were found to perform significantly better than the control group on measures of phonological awareness and reading ($p<.01$). It was found that the type of instruction given influenced reading performance in the first grade, with children who had received 'metalevel' training performing at the 70th percentile and those who had skill and drill training performing at the 52nd percentile. Teaching children how to apply phonological understanding to reading was found to be highly beneficial. However, one problem with this study is that because there was no group receiving just reading instruction, it is possible to argue that it was merely reading instruction that produced these results.

Hatcher, Hulme, & Ellis (1994) did include such a group in their study. One hundred and twenty eight six-and seven-year-old poor readers were taught in four conditions, receiving reading with phonology (R+P) training, reading alone (R), or phonological training (P) alone. There was also an untaught control group (C). The children were taught in half-hour sessions over 20 weeks. They found that the R+P group made the biggest gains in reading as measured by the British Ability Scales test of single word reading and the Neale Analysis of Reading Ability Test. On this test of single word reading the R+P group differed from the control group ($p<.01$) as did group R (p<.01) but the group receiving phonological training alone did not differ from the control group. The R+P group also outperformed the other groups on a test of text reading, but neither the R nor the P group differed from the control group. The same pattern was found for nonword reading and spelling. The specificity of the training was shown by the fact that none of the groups differed on a maths test. The influence of the training remained, with the pattern of results being the same, 9 months later. It is important to note that the gains made by the R&P group cannot be attributed to the fact that their phonological awareness skill had improved the most because their phonological awareness skills had not improved as much as in the P group. These findings provide very good evidence for the notion that making explicit links between reading and phonology will result in more progress being made in reading than training phonological skills in isolation.

In summary, it would seem that there is good evidence that giving children training in phonological skills can improve their reading performance. This is important in establishing a causal relationship between phonological skills and learning to read, and suggests that phonological skills facilitate reading development. However, it does not rule out the possibility of a reciprocal relationship such that learning to read also improves phonological awareness.

## 1.3. The Nature of Phonological Awareness Tasks

A number of studies have considered relationships between the phonological tasks themselves. It could be that the tasks measure a unitary, underlying phonological skill that is related to reading or that the tasks reflect a number of separable sub-skills that might influence children's reading development in different ways, and possibly at different times. This issue has been examined by looking at the interrelationships between different phonological measures given to the same children.

Stanovich et al. (1984) gave ten tests of phonological awareness to kindergarten children and found that the scores on all the tasks were highly intercorrelated. A principal components analysis was performed and the first principal component was found to account for 47.8% of the total variance. The seven non-rhyming tasks all loaded highly onto this one factor (.70 to .87) and the two rhyming tasks loaded at .36 and .54. Although this would seem to be clear evidence for a single unitary skill, ceiling effects on the three rhyme tasks mean that the results must be interpreted with caution.

When Wagner & Torgeson (1987) re-analysed the Lundberg et al. (1980) data they found that a principal components analysis yielded two components accounting for 53 and 14 percent of the variance. However, the proportion of common variance accounted for by the first was high (.86) with all of the measures except syllable segmentation and rhyme loading highly on it. These two variables were the only two to load on the second principal component. From this Wagner & Torgeson argued that the variance can be accounted for by a single latent ability.

However, there is also good evidence that phonological awareness tasks might be measuring different basic constructs. Yopp (1988) found two factors from a principal components analysis of ten phonological awareness tasks given to 96 kindergarten children. Phoneme blending, segmentation, phoneme counting and phoneme isolation all loaded highly on the first factor and phoneme deletion and word-to-word matching loaded highly on the second factor. Yopp argued that the two factors could represent different levels of difficulty rather than differences in skill. The second factor places a much heavier burden on memory and involves two operations, Yopp argues that the second factor is a compound factor, whilst the first factor is a simple factor.

Stanovich (1992) similarly argues for a continuum rather than different skills. Stanovich argues that phonological sensitivity could be viewed as a continuum ranging from 'shallow' to 'deep' sensitivity. Deeper levels of phonological awareness would use more explicit analysis of smaller-sized phonological units whilst shallower forms would involve larger units. Phonemes, it is argued, require more explicit guidance because the child is required to ignore the natural unity in articulation. Hence, rhyme would be regarded as 'shallow' and phoneme deletion as 'deep' (cf. Hoien, Lundberg, Stanovich & Bjaalid 1995). However, a number of studies do seem to find more than one factor accounting for variance in performance, suggesting that separate skills might be involved. Furthermore, some studies show that particular factors account for unique variance after the other factors have been accounted for which suggests that they may be tapping a different skill.

Lundberg, Frost & Petersen (1988) demonstrated with confirmatory factor analysis the separability of a phoneme factor and a syllable factor. Similarly, Bryant, MacLean, Bradley & Crossland (1990) found that rhyme explained some unique variance in reading even after phonemic awareness had been controlled for in a study of 64 four and a half year olds. This suggests that separate abilities may be involved. Muter, Hulme, Snowling & Taylor (1997) found some support for this hypothesis. Muter et al. looked at the development of phonological awareness of 38 four-year-old children over a two-year period. The results were entered into a principal component analysis, done separately for each of the three years. The results pointed to two independent factors, which they referred to as a segmentation factor and a rhyme factor. Measures of phoneme segmentation, deletion, and blending loaded highly on the first factor and rhyme detection and production loaded highly on the second.

Hoien, Lundberg, Stanovich & Bjaalid (1995) looked at a very large sample of children in two studies. In the first study they tested 128 kindergarten children (aged 7), and in the second they looked at 1509 children of the same age. The results of their principal component analysis was very similar for both studies, yielding three factors. In the second study, the first factor had strong loadings from the four phonemic measures (phoneme counting, phoneme blending, identification of initial and end phonemes). The second factor had a strong syllable loading (.98) and alone accounted for 17% of the variance. The third factor is a rhyme factor accounting for 17.1% of the variance. The phoneme factor explains more variance than others (55%), but the syllable factor (14%) as well as the rhyme factor (14%) still contribute significantly (all at $p<.001$). These results support the view that there are different levels of phonological awareness and it is possible that these correspond to the different levels of language analysis required by the tasks.

Clearly, it is hard to refute the argument that the tests of phonological awareness are testing different levels of difficulty rather than distinct processes because it could always be argued that the difficulty of the task in relation to others accounts for the unique variance. Nevertheless, the evidence does seem to suggest that different factors or skills may be involved. These skills may develop at different times and may influence the development of reading in different ways.

## 1.4. The Development of Phonological Skills

### 1.4.1. The Development of Phonological Awareness

It is possible that some tests of phonological awareness are harder than others because certain phonological skills develop later than others. There seems to be evidence to suggest that awareness of different sized phonological units develops sequentially. Liberman et al. (1974) found that phoneme tasks were possible for children over six years old but not for children younger than this. Liberman, Shankweiler, Fisher & Carter (1974) compared children's awareness of the syllable and the phoneme using a counting task. The data show that reaching criterion level in the syllable counting task was easier than in the phoneme counting at each age level.

Similar results were found by Fox & Routh (1975) who found that only children who could segment words into syllables benefited from phonic blending training, suggesting that syllable segmentation might need to develop before phonemic awareness. Furthermore, Yopp (1988) found that a rhyme discrimination task was easier than phoneme blending, phoneme segmentation, and phoneme deletion tasks.

The argument that awareness of phonological units develops in a hierarchy, that is, from the largest to the smallest unit, is supported by the work of Treiman (1983, 1986). Treiman argues that there is an intermediate level between syllables and phonemes which is the onset and rime level. This refers to the splitting of a syllable into two parts, an opening and an end section, the onset is the initial consonant or consonant cluster and the rime is the vowel and succeeding consonants in the syllable, so for example, a monosyllabic word like 'string' is split into the onset 'str' and the rime 'ing'. Treiman argues that the ability to segment phonemes is preceded by the ability to segment syllables into onsets and rime. In support of this idea Treiman (1985) found that initial consonant clusters appear to be treated as single units by children. When children were asked to determine which syllable contained a puppet's favourite sound, e.g. /s/. Some of the favourite syllables contained a favourite sound which was followed by a vowel sound (/sa/ and/sap/) or by another consonant (/sme/ and /ski/). The hypothesis was that if the linguistic level of the shared unit is influential then children should perform better when the shared unit is an onset than when it is part of an onset. In the latter case this would require segmentation at the phonemic level, which it is hypothesised develops later then segmentation at the level of the onset. Children more often failed to recognise the favourite sound in syllables like /spa/ than in syllables like /sap/ or /sa/. In the first case the opening consonant is the whole onset and in the second it is only part of the onset which is the whole cluster. Treiman used these results to argue that children find it easier to divide words at the onset/rime boundary than at any other point. She suggests therefore, that onsets and rimes are natural units for young children and that awareness of these units develops prior to awareness of phonemes. However, this study is open to the objection that syllable initial clusters may simply be difficult for children to deal with.

Goswami and Bryant (1990) argue that the smallest unit available to the young, pre-literate child are onsets and rimes. They suggest that children start to learn to read by using these onsets and rimes to form analogies between words. Goswami (1993) suggests an interactive model of reading development which suggests that as reading develops the phonology underpinning it becomes more fine grained going from onset rime coding to complete phonemic underpinning. Goswami argues that phonological knowledge and orthographic knowledge influence each other through development and suggests a number of ways in which this may happen. It is suggested that because some onsets and rimes correspond to single phonemes, for example, in 'tea' and 'do', that even if phonological underpinning is initially at the onset-rime level then some knowledge about phonemes will be developing at the same time.

Treiman and Zukowski (1991) used a word pair comparison task to look at what kinds of phonological units young children found easiest to work with. Children heard pairs of words and had to decide whether they shared sounds, these shared sounds could be at the level of the syllable, onset, rime, or single phoneme,;again a puppet was used. Forty-eight five year olds, fifty-six six year olds and fifty-four seven year olds were tested. They confirmed that children found the syllable task easier than the phoneme task. When the data were collapsed across all the age groups the proportion of correct responses for the shared beginning sound was 95% for the shared syllable unit, 82% for the onset-rime level unit, and 75% for the shared phoneme, for the shared end sound the proportions were 95%, 86% and 69% respectively. However, some ceiling effects at first grade level should be noted.

A number of other studies provide evidence for this hierarchical development hypothesis. For example, Kirtley, Bryant, MacClean, and Bradley (1989) tested sixty four children in three groups, aged five, six and seven years old. The children were required to identify which of three CVC words was the odd one out. They found that children performed worse on tasks where the two common words did not share the same rime (mop, lead, whip), and on tasks where all three words shared the same onset (cap, can, cot). They performed best on the six tasks where the common words shared either the same onset or the same rime. This suggests that children, even pre-readers are able to use onset-rime divisions in categorising words. Furthermore, the pre-readers, could categorise words on the basis of a single phoneme providing this corresponded to the word's onset.

However, a number of criticisms have been made of this model of phonological development. Tunmer & Rohl (1991) question the notion that there is a clearly defined stage in phonological development when children are aware of syllable and onset-rime divisions but are unable to segment these units into phonemes. They propose a 'pronunciation strategy' hypothesis whereby children prior to fully developing phonological awareness rely on monitoring articulatory cues. They stress the importance of the child being able to pronounce the segments in isolation. The pronunciation strategy hypothesis predicts that children will find VC syllables easier to segment than CV syllables because children would find it easier to pronounce the first phoneme of the VC syllable in isolation. However, the onset-rime hypothesis would predict the opposite because the division of the CV syllable coincides with the onset-rime division. In Treiman & Baron's (1981) study children found VC syllables easier to segment than CV syllables (77% and 56%). Furthermore, Tunmer et al. (1988) found a similar advantage for VC over CV syllables in a phoneme counting experiment (81.6% and 65.8%). These findings suggest that the use of onset-rime divisions may depend on the nature of the syllable to be divided.

Davis (1989) questions not so much the nature of the syllable used as the nature of the word used in segmentation experiments. He is critical of Treiman's work because it is based on monosyllabic words. He argues that the division made may be dependent on the fact that monosyllabic words are used, he suggests that when polysyllabic words are used the division becomes between the initial consonant and the rest of the word. Therefore, it is possible to argue that when monosyllabic words are used it might just be that the onset-rime division is in fact a kind of division between the initial consonant and the rest of the word. Carlisle (1991) also suggests that the nature of the rime may influence performance on the tasks used in the Treiman experiments. Carlisle points out that the fact that some consonant blends in Treiman's work have high error rates preceding one vowel, e.g. 'stai' but not another, e.g. 'ste', is problematic for Treiman's notion of the onset consistently being treated as a natural, universal unit of perception by young children. It would seem that Treiman's notion of the psychological reality of onsets and rimes and their place in phonological development needs to be questioned.

It is not only the distinctiveness of the onset and rime as units of language that has been questioned. The hierarchical model of development has also been challenged. Seymour & Evans (1991) presented eighty children in three age groups (Reception, Year 1 and Year 2) with monosyllabic words and asked them to divide them into two parts, three parts or as many parts as possible. For example, the target word 'ground' could be divided into 'gr-ound', 'gr-ou-nd' or 'g-r-o-u-n-d'. A variety of other phonological awareness tasks were also administered. Their results did not support the hierarchical model. Children who had not begun to read had some success in a rhyme task but were unable to segment at any level. Furthermore, they found no evidence of onset/rime competence emerging ahead of other levels of segmentation. The year one children segmented the word into two parts using onset/rime divisions for only 7.5% of responses in which the children managed to segment into two parts (26% of responses were 'correct' in terms of being divided into two parts). However, the poor performance overall must be noted. Contrary to the hierarchical model they found that when given instructions that emphasise letter-sound associations, phonemic competence emerges ahead of intermediate onset/rime competence. The year two children showed a strong preference for phonemic segmentation with 80% correct responses for phonemic segmentation, 70% for two part responses and 68% for three part responses. With these older, literate children this is possibly because the children were segmenting the words with reference to orthographic codes formulated in terms of letter sequences, indeed Seymour & Evans place great emphasis on the importance of the method of instruction in influencing the results. Nevertheless, the pattern of errors produced also questions the superiority of the onset/rime division. Responses using an onset/rime division were hardly ever given in the tasks requiring segmentation into three parts or into as many parts as possible. Furthermore, in line with the comments made by Davis (1989) and Carlisle (1991) it was shown that the type and complexity of the word was an important factor with error rates being higher for complex items (containing consonant clusters) than simple targets.

Duncan, Seymour and Hill (1997) provide further evidence which questions the emphasis some have placed on the role of large units of phonology, such as onset and rime units, in reading acquisition. In a series of experiments following 60 children from the nursery to the reception class they demonstrate that phonemic awareness rather than an awareness of onsets and rimes underpins early reading development. Duncan et al. examined two groups of children, those who had good pre-school rhyming skills and those who had less good rhyming skills. The children were tested on a number of tasks in their reception year. A nonword reading task was administered in which the nonwords were based on real words. The nonwords were derived either from the onset + rime, from the body + rime, from the body + coda or from the onset + peak + coda of the real words. It was predicted that if children use large units in their early reading an advantage would be seen for nonwords which shared rime units with real words. However, this was not found to be the case, no advantage for nonwords which shared rime units with the real words was found. In a second experiment the children were asked to identify which spelling pattern in a word made the sound the experimenter gave them. It was found that children were most accurate at identifying the smaller spelling units, spelling patterns which corresponded to rime units were not well identified, even by the group of children with good rhyming skills. It would seem therefore that children may not have a tendency to rely on large units of phonology in their early reading as earlier assumed.

In summary, it would appear that although there is good evidence that children find some phonological awareness tasks easier than others and that this is in some way related to their age and level of literacy development, the notion of a rigid hierarchical model of development needs to be questioned. It is possible that these somewhat contradictory results could be explained by the different tasks used in different studies which place differential cognitive demands as well as differential linguistic demands on children. Furthermore, the role of instruction is also important. It does seem probable that phonemic awareness is likely to develop with increasing literacy instruction which focuses children's attention on letter-sound correspondences. Seymour and Evans suggest that their results were influenced by the method of literacy instruction that the children received. Although the notion of a rigid model of hierarchical development of phonological awareness skills must be questioned, it would appear that a general trend exists for children being able to manipulate increasingly smaller units of phonology with age, with an awareness of syllables emerging before an awareness of phonemes. However, it is important to note that although performance in phonological awareness tasks follows this pattern, children appear to rely on phonemic awareness rather than an awareness of larger units of phonology in their early reading development.

### 1.4.2. The Development of Phonological Representations

Phonological awareness refers to the ability to consciously reflect upon speech sounds. However, it is clear that children use these speech sounds implicitly in speech production and perception. It has been suggested that developmental trends in phonological awareness may reflect changes in the nature of children's representations of speech. The development of children's phonological representations is considered in this section.

There is some evidence that very young infants are able to discriminate speech contrasts in a categorical, adult-like manner (Aslin, Pisoni & Jusczyk, 1983, Werker, 1991). Eimas, Siqueland, Jusczyk & Vigorito (1971) demonstrated that infants between the ages of one to four months are sensitive to changes in synthetic speech stimuli, for example, the difference in voicing between the stimuli /pa/ and /ba/. This was shown by the infants' sucking patterns, a change in stimuli that crossed the boundary between b and p produced a marked increase in sucking rate, a change which did not cross this boundary did not produce an increase in sucking rates. This finding suggests that very young infants are sensitive to the same phonetic distinctions as adults. Although these infant perception studies would seem to suggest that children may represent phonology in the same way as adults from the outset, the studies are limited in a number of ways. It is likely that the infants in these studies show an ability to distinguish acoustic patterns rather than an ability to respond to the sounds as phonological units. Studdert-Kennedy (1991) suggests that these psychophysical studies show that infants are able to categorise certain acoustic patterns which occur in speech. These studies, therefore, may not provide convincing evidence that children represent speech in the same way as adults but merely suggest an ability to distinguish between acoustic patterns.

There is considerable evidence that young children's initial words are represented not as sequences of independent phonemes but as holistic patterns, on the basis of overall acoustic or articulatory form. It has been suggested that throughout development these representations become increasingly fine grained and segmental to become adult like. It is proposed that this restructuring process is driven by the child's expanding vocabulary. When the lexicon includes only a few words not many different articulatory routines are needed, therefore allowing holistic representation. However, as the number and complexity of items in the child's lexicon increases so too does the need to discriminate between increasing numbers of similar sounding lexical alternatives, therefore representations are forced to become increasingly segmental. As Nittrouer, Studdert-Kennedy & McGowan (1989) suggest:

"As the number and diversity of words in the child's lexicon increase, words with similar acoustic and articulatory patterns begin to cluster. From these clusters there ultimately precipitate the coherent units of sound and gesture that we know as phonetic segments." (p. 131)

The evidence for suggesting that children do not represent words phonemically or segmentally, as adults do, is considered below. Firstly, there is evidence from the early speech productions of young children that words are represented holistically. Ferguson & Farewell (1985) examined the productions of young children and observed that there was considerable variability between words such that phonetic segments pronounced correctly in one word were not pronounced correctly in another word. It is suggested that words, at this stage, are not made up of segments comparable across words but that each word would seem to be made up of a unique articulatory routine. Although some of this variability may be due to motoric limitations, it is likely that it is largely due to the way in which words are represented at this stage.

Nittrouer, Studdert-Kennedy & McGowan (1987) investigated the acoustic structure of syllables produced by children aged 3, 4, 5 and 7 years old, and adults. The production of the fricatives /s/ and /sh/ before two different vowels, /I/ and /u/ was examined. Coarticulation is the overlapping of movements in the production of neighbouring phonetic segments. It was hypothesised that if children relied more on holistic representations of the syllables they would tend to produce the syllables as undifferentiated wholes and show greater effects of coarticulation. Two developmental trends were noted; firstly, the extent to which subjects differentiated between /s/ and /sh/ increased with age; secondly, the extent to which these fricatives were coarticulated with the vowels which followed them decreased with age, younger children showed more coarticulation than older children and adults. Nittrouer et al. argue that this strong fricative-vowel coarticulation observed in young children is due to a greater overlap between their consonant and vowel lingual gestures and that this in turn, is the result of phonological information being represented in a holistic manner.

Nittrouer & Studdert-Kennedy (1987) also showed that young children were more sensitive to coarticulatory effects than older children and adults in their speech perception as well as speech production. Adults and children aged 3, 4, 5 and 7 were asked to identify either /sh/ or /s/ from synthetic speech. Again it was reasoned that if children were relying on holistic representations of the syllables they would tend to perceive the syllables as undifferentiated wholes and again show greater effects of coarticulation. This effect of coarticulation was observed with the younger children. Young children's identification of the initial fricative was found to be more influenced by the syllable information given by the vowel segment that followed it; adults and older children were found to be more influenced by the frequency of the fricative. The effect of coarticulation decreased with age, providing support for the hypothesis that phonological representations become increasingly fine grained with age.

The speech perception skills of children were also examined by Walley (1988) in a gating task. Five-year-old children and adults listened to words to which white noise had been added or which replaced fricative and nonfricative segments in all positions of the word. Subjects were asked to rate how 'noisy' the stimuli were. It was found that adults rated the stimuli as 'noisier' when the noise replaced an initial segment. Children also gave high ratings to words with noise added or replacing fricatives, however, they did not appear to accord a special status to the initial segment. It was argued that children use information distributed across the whole word in distinguishing speech sounds, suggesting they do not employ segmental representations during lexical access.

Treiman & Breaux (1982) examined children's speech categorisation in a paired-associate learning task. Four-year-old children were taught spoken nonsense syllables as the names of animals. The performance of the 4 year olds was compared with that of adults. It was found that in the initial learning phase children were more likely to confuse globally similar labels (e.g. bis for diyz) than adults. Adults were more sensitive to phoneme similarities and tended to confuse items sharing a common phoneme (e.g. bis for boon). Again, this suggest that the children's representations were based on holistic acoustic patterns.

It would seem that there is good evidence to suggest that children's initial phonological representations are holistic and become increasingly phonemic with development. It was suggested above that this restructuring process is driven by vocabulary growth, particularly during the vocabulary growth spurt around the age of two, in which large numbers of new items are added to the child's lexicon. Luce, Pisoni and Goldinger (1990) suggested a Neighbourhood Activation Model (NAM) of adult speech perception which provides a useful framework within which to consider this restructuring process. Luce argued that all words have 'neighbourhoods'. A 'neighbour' is defined as a word that can be transformed into the target word by the addition, substitution or deletion of one phoneme. Some words have more neighbours, or denser neighbourhoods, than others. Luce argued that the speed and accuracy of speech perception is strongly dependent on the word's neighbourhood structure. This model of adult perception is clearly dependent on segmental representations. However, it provides a useful framework within which to examine a possible developmental restructuring process. Charles-Luce & Luce (1990) statistically investigated the words in the lexicon of 5-and 7-year-old children and compared them with adult lexicons. They found that the lexicons of the children had fewer neighbours than the words in the adult lexicon. It is suggested that as a result of this children are able to employ global recognition strategies because the words in the child's lexicon are more discriminable than those in the adult lexicon.

Walley (1993) suggests that not all lexical items will be restructured concurrently, it is likely that some words will be restructured segmentally before others. There are a number of possible factors which might influence this process.

For example, the study of Charles-Luce and Luce would suggest that words with more neighbours would be more likely to be restructured than words with few neighbours. Metsala (1997a) found that 7-and 9-year-old children required more bottom up input from word onset to recognise words with few neighbours in children's lexicons than did 11-year-old children and adults. However, for frequently heard words with many neighbours the pattern differed, young children's recognition was based on the same amount of bottom up input as for the older children. Furthermore, for these words children displayed a similar amount of segmental processing.

Familiarity has been shown to influence children's speech perception. Barton (1976, 1980) investigated the ability of children between the ages of 27-35 months to discriminate between minimal pairs of words, e.g. lock/log; clown/crown. He found that the children were much more likely to succeed in this task with words they knew well than with words they did not know. Walley and Metsala (1990, 1992) in a task which required 5 and 8 year olds to detect speech errors, found that their sensitivity to the mispronunciations was substantially influenced by age of acquisition estimates. Again this would seem to suggest that the familiarity of stimuli influences children's ability to recognise spoken words.

While there has been considerable acceptance of this general developmental trend from holistic representation of speech to gradually refined segmental representation, some have questioned the continuation of this process into early childhood. Gerken, Murphey & Aslin (1995) have argued that much of the evidence showing differences between adults and children may be based on task difficulty, rather than on differing lexical representations. Further, from the above findings on the influence of familiarity on speech recognition, it would seem reasonable to suggest that the type of words used in experiments might affect the findings of studies. For example, it may be that studies of phonemic contrast acquisition using nonsense syllables as stimuli may underestimate children's ability to discriminate words.

Gerken et al. argue that at least some of the differences observed between children and adults may reflect developmental changes in general cognitive abilities demanded by the task rather than changes in the representation of spoken words per se. They argue that many of the tasks used in the studies described above may be demonstrating developmental differences in memory or attention or metalinguistic skills. They asked 3 and 4 year old children to distinguish an invariant target word, *little* , from phonetically similar nonword foils and aimed to show which phonetic properties of a foil would make it more or less confusable with the target, and whether these properties differed for children and adults. The foils changed either the onset or the vowel or the coda of the word, e.g. /nItl/, /lEtl/ or /lIgl/. It was argued that this task placed less cognitive demands on the younger children because they were only required to remember a single word throughout. It was shown that children were more likely to mistake /nItl/ for *little* than the other foils, as this foil differed from the target word in only one feature they suggest that children may represent spoken words in terms of features in the same way as adults do.

Gerken et al. also attempted to assess whether foils which differed in more than a single segment were more confusable than foils which included the same aggregate of featural change to a single segment. In this experiment the target word was *lick*; the foils which differed by two features on one segment were gik and lif; the foils which differed by one feature on each of the two segments were zig and zek. It was found that children made more target responses to foils that differed from the target by 2 features on a single segment than they did to foils that differed by one feature on each of two segments. This suggests that children may represent phonetic features and associate these phonetic features with segmental positions in the word. However, it should be noted that the difference between responses to lif and to zig were not statistically significant, although the trend was for more responses to lif than to zig. Therefore, conclusions from this study remain tentative. However, the Gerken et al. study does raise the possibility that children may begin to represent words segmentally earlier than previously thought. In summary, although there is a clear trend in development for children to represent speech in an increasingly segmental fashion, it is possible that some tasks may underestimate children's ability to represent speech segmentally as a result of being too cognitively demanding.

### 1.4.3. The Relationship between Phonological Awareness and Phonological Development

It has been argued by some that the role of conscious awareness of phonology in learning to read may have been over-emphasised (Hulme & Snowling, 1992). It is suggested that it is not the explicit awareness of phonology which is important in reading development, but the quality of the underlying phonological representations themselves. According to this view phonological awareness tasks tap the phonological representations children are able to use implicitly in their reading development. There is some evidence to support this position.

Cossu, Rossini, & Marshall (1993) studied the reading development of children with Down's Syndrome. They found that due to the cognitive limitations of these children they were unable to perform phonological awareness tasks, however, they were still able to learn to read. Such findings suggest that metacognitive awareness of phonology may not be the most important factor in determining reading success.

There is also evidence that the phonological problems of poor readers may involve more than problems purely of phonological awareness. Poor readers appear to have problems with short-term memory (McDougall, Hulme, Ellis & Monk, 1994), with naming, that is, in accurately producing the name of an item (Katz, 1986; Snowling, Wagtendonk & Stafford, 1988 ) and with nonword repetition (Snowling, Chiat & Hulme, 1991). The diverse range of phonological deficits suggests that dyslexics may experience more fundamental problems with phonology than purely metacognitive phonological awareness. The relationship between reading and memory skills is reviewed in detail in Section 1.5.3.

Snowling, Wagtendonk & Stafford (1988) considered the naming deficits of dyslexic children and argued that their difficulties stemmed from "faulty or impoverished (phonological) representations" (p.80). Hulme & Snowling (1992) in discussing a case study of JM, a dyslexic boy, conclude that his difficulties in word and nonword repetition are not the result of an inability to consciously reflect upon phonology but of inaccuracies in the phonological representations themselves. Fowler (1991) proposes a 'segmentation hypothesis' and Metsala & Stanovich (1995) a 'lexical restructuring hypothesis' suggesting that the phonological deficits seen in dyslexia can be considered in terms of them having more holistic and less segmental phonological representations, like those of younger, normally developing children, as discussed in Section 1.4.2. Elbro, Nielsen & Petersen (1994) frame it in terms of a distinctness hypothesis, arguing that children who become dyslexic have poorer access to the most distinct variants of spoken words than other children.

Swan & Goswami (1997) attempted to examine the hypothesis that the phonological awareness skills of dyslexic children depend on the accuracy of the underlying phonological representations. They did this by comparing the dyslexics' performance on phonological awareness tasks with words they could correctly name (indicating a complete phonological representation) and words they named incorrectly (indicating an incomplete representation). They found that differences between dyslexics and controls on phonological awareness tasks involving syllables, onsets and rimes disappeared once representational adequacy was taken into account.

However, differences continued to be found for tasks at the phonemic level. Those words which did have accurate phonological representations (as measured by the naming task) did not appear to be sufficiently developed to support a phonemic level of analysis. Like Fowler's (1991) segmentation hypothesis they propose a delayed phonological organisation hypothesis. One possible problem with this study is in the use of naming; this may be a rather insensitive index of the accuracy of the phonological representation underlying the word, it may be that a more sensitive measure would have also accounted for the dyslexic's performance on the phonemic tasks.

In summary there appears to be some evidence to suggest that it is not phonological awareness per se which is important for reading development but the quality or integrity of the underlying phonological representations themselves. Furthermore, it has been suggested that the incomplete or 'fuzzy' phonological representations of poor readers may be the cause of their reading difficulties. However, evidence for how these phonological representations are accessed and used by beginning readers, and how this relates to performance in phonological awareness tasks, is at present scant.

## 1.5. Other Measures of Phonological Skill

If a distinction is made between the conscious awareness of phonological representations and the underlying phonological representations themselves is it possible to tap this phonological information in tasks that do no require explicit awareness of phonology ? One suggestion is that verbal short-term memory and speech rate tasks tap these underlying phonological representations and so provide an alternative measurement of the quality of phonological representations to phonological awareness tasks. Such tasks often require the use of phonological information but do not demand explicit awareness of it. This section reviews the evidence which suggests a link between performance on these tasks and reading development.

### 1.5.1. The Relationship between Memory and Speech Processes

There is good evidence that verbal short-term memory skills are related to language processes and to the mechanisms responsible for speech. Given what we know about the relationship between these mechanisms and reading it is not surprising that short-term memory skills are related to reading skills.

Verbal short-term memory is frequently discussed in terms of the working memory model (Baddeley & Hitch 1974) and in particular in terms of an articulatory loop. The articulatory loop is a limited capacity system which relies on subvocal rehearsal to refresh decaying traces. There is good evidence to suggest that the articulatory loop makes use of a speech-based code. Baddeley, Thomson and Buchanan (1975) found that the number of words that could be remembered was related to the length of the to-be-remembered items: memory span was found to be larger for short words than for long words. Differences in between items and subjects articulation rate strongly predicted variations in memory span. This finding was interpreted in terms of subvocal rehearsal: memory span is directly related to the rate at which items can be rehearsed before the trace decays to a point at which it is irretrievable. A second piece of evidence suggesting the use of speech coding in short-term memory is the phonemic confusability effect. That is, phonemically confusable items are less well remembered than non-confusable items (Conrad 1964).

Although there is good evidence that the articulatory loop relies on a time dependent, speech-based code it is also clear that other factors have an influence on short-term memory. Hulme, Maughan & Brown (1991) argued that long-term memory representations of the phonological forms of items are important in supporting the retrieval of partially decayed words held in a rehearsal loop. It was found that memory span for words was greater than memory span for nonwords, which have no representation in long term memory. This suggests that short-term memory is also dependent on the operation of long-term memory mechanisms, with representations of the phonological forms of spoken words being used to support the recall of degraded traces in short-term memory (Hulme et al., 1997)

### 1.5.2. The Development of Verbal Short-Term Memory

A number of studies have suggested that increases in memory span with age are related to the developmental increases in the rate at which children can articulate words (Hitch & Halliday 1983, Hulme, Thomson, Muir & Lawrence 1984, Hulme & Tordoff 1989). One possible explanation is that changes in speech rate lead to faster rehearsal rate and thereby memory span increases with age. However, a number of studies question this mechanism.

Firstly, as mentioned above, it has been shown that factors other than articulation rate are involved in short-term memory. Henry and Millar (1991) tested the memory span of 5 and 7 year olds for words, controlling for the children's articulatory rate. Differences in memory span were still found suggesting that other processes must contribute to the development of short-term memory. Roodenrys, Hulme and Brown (1993) compared the memory span of children aged 5-6 with children aged 9-11 for words and nonwords of differing length. Their results revealed significant main effects of item length and item type for both age groups. When speech rate was controlled, significant effects of item type and age were found but no interaction was found. This suggests, therefore, that the differences in recall between subjects of different ages and between the item of different types cannot be attributed to differences in speech rate alone.

Further studies suggest that it is not so much the covert speech processes in rehearsal that are important in predicting memory span but the overt speech output processes involved in recall. Henry (1991) gave 5-year-old children a probed recall task which did not require full verbal output. When full verbal recall was eliminated the word length effect and the phonemic similarity effects did not occur. This suggests that both of these effects may stem from the process of saying a list of items aloud rather than from rehearsal in the case of the word length effect or confusion at input in the case of the similarity effect.

Cowan (1992) investigated the influence on output processes further and found that it was the interword pause durations in recall that correlated with span rather than the mean word durations themselves. It was suggested that the decaying traces of words are reactivated during these interword pauses at recall. The pauses, however, are too short to allow for covert rehearsal and therefore another mechanism of reactivation must be involved. It would seem, therefore, that speech rate does not affect recall simply because it affects the rate at which rehearsal can take place but also by placing constraints on the speed of recall.

### 1.5.3. The Relationship between Short-Term Memory and Reading

There is some evidence that performance in reading is linked to short-term memory span, and in particular to verbal short-term memory. A number of studies have shown that poor readers typically perform badly on tests of verbal short-term memory (Jorm 1983, Brady, Shankweiler & Mann 1983, Brady, Mann & Schmidt

1987). Furthermore, the relationship between reading and memory has been shown to be limited to memory for verbal rather than visual material. Liberman, Mann, Shankweiler and Werfelman (1982) presented 8-year-old good and poor readers with a series of items and asked them to indicate whether or not the item had been presented previously. The stimuli consisted of either nonsense syllables, unfamiliar faces, or nonsense line drawings. They found that differences in memory between the two groups were restricted to performance with the linguistic stimuli.

Although a relationship between verbal short-term memory and reading has been established, the nature and causal status of this relationship are less clear. Reading and memory could be linked in a number of different possible ways. It is possible that differences in short-term memory between good and poor readers may reflect differences in the encoding of information, in particular in the encoding of phonological information. It may also be the case that short-term memory is linked to reading through processes such as the learning of letter-sound correspondences or the process of phonic blending. That is, good short-term memory facilitates these processes and as a result leads to good reading. Finally, short-term memory may be involved in comprehension. Alternatively good reading skills and good verbal short-term memory may both be signs of well developed phonological skills, but there may be no direct link between short-term memory skills and the process of learning to read.

One way in which reading and short-term memory may be related is in the encoding of phonological information. It has been suggested that poor readers encode phonological information differently from good readers. Shankweiler, Liberman, Mark, Fowler & Fischer (1979) and Mann, Liberman and Shankweiler (1980) found evidence that the phonetic confusability effect is stronger in poor readers than in good readers, that is, good readers were more severely affected by item confusability than poor readers. As suggested in the previous section the phonetic confusability effect is said to reflect the contribution of the phonological storage component of the phonological loop. Shankweiler et al. (1979) and Mann et al. (1980) have used the evidence of stronger confusability effects in poor readers to argue that poor readers have problems with phonological coding in short-term memory.

However, the pattern of results in these studies appear to reflect a range effect: the poor readers performed worse overall in the memory task than the good readers and low levels of performance on the task appear to be responsible for decreases in the phonemic confusability effect. Johnston (1982) compared the memory span for lists of confusable items in groups of 9-, 12-and 14-year old dyslexic children. Performance was compared with chronological age matched controls and reading age matched controls. Although differences in span were found between the dyslexic children and their chronological age matched controls there was no difference in performance between the dyslexic groups and the reading age controls. No differences were found between the groups in terms of confusability effects.

Johnston, Rugg and Scott (1987) argued that some differences in confusability effects between good and poor readers found in the studies described above could result from the fact that the good and poor readers are asked to recall lists of the same length. It is possible that effects are found because the lists employed are more demanding for the poor readers than for the good readers. They found that when levels of task difficulty were controlled for differences in confusability effects between the groups were abolished. The poor readers were influenced by phonetic confusability as much as the normal readers suggesting that they are using speech coding in short-term memory in much the same way as the normal readers, although with less efficiency.

### 1.5.4. The Nature of the Causal Relationship between Memory Skills and Reading

A number of longitudinal studies have attempted to establish the nature of the causal relationship between short-term memory and reading. Jorm, Share, MacLean and Matthews (1984) gave a large group of five year olds a sentence memory task when they first started school and then tested them on memory and reading tests at age seven. They found memory scores at age five correlated strongly with later reading scores when the effects of age and IQ are controlled for. This finding suggests that short-term memory problems may in some sense contribute to reading problems rather than the other way round. However, it should be noted that the measure of short-term memory used in this study was a sentence memory task which is not a typical short-term memory task. It is possible that different processes may be involved in remembering sentences as opposed to single words and skills other than verbal short-term memory may also be important.

Mann & Liberman (1984) tested 62 children at the end of their kindergarten year at age 6 and then retested them a year later. It was found that verbal memory performance predicted reading one year later, again suggesting a causal relationship. However, the fact that no measure of general intelligence was taken into account means that the possibility that the poor readers also had poorer general intellectual abilities cannot be ruled out.

Gathercole and Baddeley (1993) tested 150 4-year-old children within 6 weeks of school entry on reading, vocabulary, general intelligence and verbal short-term memory. The children were then retested at ages 5, 6 and 8 years old. A nonword repetition task was used as the measure of phonological memory. There were 70 eight-year-old children who had been unable to read at age 4. Their nonword repetition scores at age 4 were significant predictors of reading performance 4 years later controlling for age, IQ and vocabulary knowledge. Three reading tests were given, a test of reading comprehension, a single word reading test and a reading test in which the child was given a sentence with a missing word and was asked to choose which of a number of words was the correct word. Age four memory scores only significantly predicted performance in the missing word reading test. They argue that this test involves a greater element of phonological recoding than the single word reading test and the Neale, which they argue may largely test sight vocabulary.

When performance on this missing word reading test was used as the reading measure, cross-lagged correlations between repetition at age 6 and later reading were significant, whereas there was no significant relationship between the memory measure and later single word reading. When single word reading was used as the measure of reading the correlation between age 5 nonword repetition and age 6 reading was .52, the converse relationship between age 5 reading and age 6 nonword repetition was .39. However, the difference between these two correlations was not significant which suggests a reciprocal relationship between the two abilities. It would seem that short-term memory skills play some causal role in reading or at least that a reciprocal relationship exits between the two abilities. However, as mentioned above the statistical method of cross-lagged correlations has been severely criticised (Rogosa, 1980). Gathercole and Baddeley argue for a causal link between memory and reading and suggest that deficits in phonological memory are the cause of language impairments. They suggest that memory is important in terms of both the learning of basic letter-sound correspondences and in providing a storage of the sound segments of words when decoding them.

It should be noted, however, that there are a number of problems with using nonword repetition as a measure of phonological memory. It has been argued that repetition is a complex task which involves a number of different processes in addition to phonological memory (Snowling, Chiat and Hulme 1991). Repetition involves processes of phonological segmentation and assembly of articulatory instructions as well as phonological memory. As a measure, therefore, it taps the child's existing knowledge of phonology used in processing words in speech, for example a child's understanding of the prosodic nature of language. Therefore, it cannot be said to be a measure of memory independent from phonological processing. Snowling, Chiat and Hulme (1991) argue, therefore, that the causal direction is reversed and that impaired phonological skills result in poor repetition skills rather than the other way around.

It is possible to argue that both poor short-term memory and poor reading are the result of the same underlying language problems. Wagner, Torgeson, Laughon, Simmons and Rashotte (1993) provide some evidence for interrelationships between memory and phonological awareness tasks. A large number of phonological awareness measures, short-term memory measures and naming tasks were given to kindergarten and second grade children. Confirmatory factor analysis revealed four correlated phonological ability factors for the kindergarten children, labelled Analysis/Working Memory (with loadings from short-term memory measures and phoneme deletion), Synthesis (measures of blending), Isolated Naming (naming isolated digits and letters) and Serial Naming (naming series of letters and digits). For the second grade children the results were very similar but the Analysis/Working Memory factor was now differentiated into two separate, highly correlated factors. The phonological factors were independent of general ability and predicted reading performance. Wagner et al. (1993) argued that the phonological awareness tasks and the memory tasks both tap the quality of the underlying phonological representations and it is these which affect children's reading development.

McDougall, Hulme, Ellis and Monk (1994) looked at the relationship between speech rate, memory span and reading. They tested 69 children between the ages of 7- and 10-years-old on memory span for words and nonwords of different lengths, speech rate and a measure of single word reading. There was a significant relationship between memory span and reading skill. However, the differences in memory span between good and poor readers were explained in terms of the differences in speech rate. When reading ability was predicted memory span did not account for any significant variance in reading once speech rate had been accounted for, although a measure of phoneme deletion still did. This finding provides support for the idea that short-term memory and reading are related because they both reflect some kind of underlying phonological skill. The finding that speech rate is a more powerful predictor of individual differences in reading suggests that short-term memory may only be related to reading to the extent to which it taps individual differences in speech rate. McDougall et al. suggest that speech rate provides a measure of the speed and efficiency with which the phonological representations the child knows can be activated. The impaired memory span of poor readers could, it is argued, result from a slow rate of processing information in short-term memory as measured by speech rate. This finding challenges the notion of a causal relationship between short-term memory and reading by suggesting that short-term memory problems are merely an index of other phonological deficits, and it is these deficits that explain both memory and reading problems.

### 1.5.5. Summary

The argument that short-term memory tasks tap underlying phonological representations is an important one and it appears that there may be no direct link between short-term memory problems and reading difficulties. Rather deficits in short-term memory tasks and deficits in phonological awareness tasks both might be interpreted as signs of an underlying deficit in phonological representations which in turn cause reading problems.

## 1.6. Models of Reading Development

### 1.6.1. The Function of Models of Reading Development

A model of reading development may operate on a number of different levels. A theory of reading development might describe the knowledge and skills that are acquired, and their order of acquisition. Such models can be helpful but are sometimes limited because they can become descriptions of behaviour offering little explanation of the mechanisms which give rise to the behaviour. Other models, in particular computational models, attempt to explain the underlying psychological mechanisms through the use of simulation. Such models have great potential to enhance our understanding of reading development, however, there are also problems with this approach.

### 1.6.2. Stage Models of Reading Development

Stage models attempt to describe reading behaviour at a number of points in development and to specify the order in which skills are acquired. Marsh et al. (1981) suggested four stages of reading development. In stage one, learning involves rote learning and 'linguistic guessing', when children in this stage face an unknown word they may attempt a guess using the linguistic context but will not use the phonological features of the word. Stage two is referred to as 'discrimination net guessing' and in this stage children will begin to use the visual features of an unknown word. By stage three, 'sequential decoding', children begin simple decoding of CVC words. This is further developed in stage four, hierarchical decoding, in which the child makes use of more complex decoding skills and begins to use analogy as a strategy. Marsh et al. argued that it was the growth in the child's sight vocabulary which leads the child to move into sequential decoding. However, this has been questioned by work which suggests that any growth spurt in the child's reading vocabulary does not occur until after the development of phonic skills (David & Williams 1974).

Frith (1985) devised a model of reading development based on Marsh's model. Frith's model included only three stages. Frith combines Marsh's first two stages into one stage. This first stage is referred to as the logographic stage during which the child relies on instant recognition of words based on salient visual features. If a child in this phase does not know a word he or she will often refuse to respond although they may make some response based on the available context. The second stage in Frith's model is the alphabetic phase in which the child begins decoding grapheme by grapheme: letter order and phonology become crucial at this stage. The third and final stage of reading development is the orthographic stage in which there is an instant analysis of words into orthographic units without phonological conversion. Frith suggests that all these strategies remain available to the child at a later stage but that once the orthographic strategy has been established the previous strategies may be less accessible. Frith argues that a breakthrough to a new stage of development comes with the merging of the old and new strategy. The force for development is thought to emerge from the asynchrony between reading and writing development. Reading and writing are assumed to proceed out of step, the sequential nature of writing is said to force the change from the logographic to the alphabetic stage. The sequential processing involved in writing, it is suggested, gives the child an opportunity to detect and later use grapheme-phoneme correspondences as a strategy in reading.

There is some empirical evidence to support Frith's model. Seymour and Elder (1986) followed a class of five year olds through their first year at school and reported that almost all the children in their first year at school were logographic readers. Although at the end of this year they were able to recognise between 30 and a 100 words plus they were largely unable to read unfamiliar words and in attempting to do so little evidence of sounding out was found. Furthermore, reaction times were influenced by word length and errors were often words that were visually similar to the target word. There is also some evidence for Frith's claim of a dissociation between reading and writing. Bradley and Bryant (1979) and Bryant and Bradley (1980) found children who, due to their limited logographic reading, could read words that they could not spell.

However, there are a number of problems with these stage models. Firstly, both the Marsh et al. and the Frith model suggest that children rely on rote memory and visual strategies when they first start to learn to read. However, there is evidence to suggest that children are using phonology from the very early stages of learning to read. This evidence is reviewed below. The stage models described above are based on 'dual-route' theories of adult reading which suggest that words can be read by using one of two distinct mechanisms: a lexical route enables the recognition of a word directly from its orthographic form, and a second route enables pronunciation through the use of grapheme-phoneme correspondences. The first lexicon is established in the logographic phase whereby a system is developing which enables recognition on the basis of visual features. However, this notion of distinct visual and phonological routes has been questioned, as discussed in Section 1.6.4.

The assumption of a necessary and 'natural' logographic stage of reading development is called into question by a study of German speaking children. Wimmer and Hummer (1990) found that, in contrast to English speaking studies, German speaking children at the beginning stages of reading rely on alphabetic strategies and not logographic strategies. Fifty-six Austrian children with an average age of 7 were studied. Twenty-eight of these children were 'delayed' readers and twenty-eight were 'normal' readers. The children were given a variety of phonological awareness tasks. It was argued that if these children relied on logographic strategies, then given brief exposure to familiar words, they should find it easier to identify these words but not non-words. Indeed, a difference was found between the words and nonwords. However, they argue that such a difference results from a combination of incomplete reading followed by word guessing. The children's errors did not reflect responding to visually similar nonwords. Furthermore, a high correlation was found between word and nonword reading and word reading and grapheme-phoneme knowledge. The children's errors were categorised into logographic errors (responding with no similar letter) and alphabetic errors (response with the same first letter). There were few logographic errors and the majority of errors were nonwords which suggests that an alphabetic rather than a logographic strategy was used. Wimmer and Hummer suggest that their findings cast doubt on the 'naturalness' of the logographic stage and the late emergence of alphabetic processes.

Stuart & Coltheart (1988) provide good evidence that children use phonology at an earlier stage of reading than had previously been suggested. They suggest that children who possess phonological skills prior to learning to read will use their phonological skills from the beginning, whereas children who are not phonologically skilled will treat reading as a visual memory task. They tested 36 nursery children and followed them throughout school, 23 remained in the sample. Six phonological tests were given in the nursery (rhyme production, rhyme detection, supplying final syllable and final phoneme, segment initial phoneme), the syllable, phoneme and segmentation tasks were repeated again at the end of the children's first year at school. The children's reading errors were categorised into six groups. They argued that a preponderance of a particular kind of error suggested the use of phonology, for example, errors which included the beginning letter or the beginning and end letter the same as the target may be said to be the result of some degree of phonological processing, whereas errors which contain little relevant information may be said to indicate a lack of phonological processing. They found that children who had good phonological skills from the beginning of reading instruction made more 'phonological errors' in reading from the beginning. This, they suggest, means that children who are phonologically able before they learn to read do not begin reading logographically.

Ehri (1992) suggests a stage model of reading development which proposes that children use phonology from the outset and in doing so challenges traditional dual-route approaches to reading development. Ehri argues that the notion of two routes, a visual and a phonological route is at odds with the available evidence of how children learn to read. If, as dual-route theorists would argue, irregular words are read using phonological recoding and regular sight words are read using visual strategies then a difference in processing speed for these two types of word would be expected. However, Lovett (1987) found no difference in normal readers' speed to read regular and irregular words that were known by sight to the children, this suggests that the two word types were processed similarly. Furthermore, Treiman & Baron (1983) found high correlations between performance with irregular and regular words (.73) and performance with irregular words and nonsense words (.67).

Ehri argues that the connections formed in memory between the written word form and its pronunciation are not arbitrary and learned by rote but that the visual route is 'paved with phonology' from the outset. She argues that children use their knowledge about letter-sound relations to form these connections from very early on. Ehri proposed three phases of reading acquisition: visual cue reading, phonetic cue reading, and phonemic map reading. The visual cue reading stage may be compared to a logographic stage in which children read by remembering visual cues. Masonheimer, Drum & Ehri (1984) studied children at this stage by looking at their response to environmental print. Children aged between 3 and 5 were shown words they knew as environmental print (e.g. 'MacDonalds', or 'Pepsi') without the environmental cues and found that the children failed to read the words. However, Ehri argues that this stage is short in duration and a shift in the child's reading occurs as soon as the child learns names or sounds of most of the alphabet.

Children at this stage will use their letter-sound knowledge to form connections between the spellings of words and their pronunciations. Connections in this phase are said to be systematic rather than arbitrary. At first children form partial associations, perhaps using only one or two letters to form connections. These partial associations between letters in a word and the phonemes for which they stand are automatically activated. These associations are formed early on in reading development and before the child is able to generate all the letter sounds present in any given words and able to blend them together. This was demonstrated in an experiment done by Ehri & Wilce (1985) in which children at the beginning stages of reading were taught to associate strings of letters (cues) with spoken words. Two types of cue were included in the experiment. One set of cues were visually distinctive, containing visually distinctive letters and printed in different size print, and one set containing letters that corresponded to the sounds in the target. It was argued that if children used a visual strategy they would find the visually distinctive cues easier to learn, but if they were using phonological information then they would find the 'phonetic cues' easier to learn. They found that prereaders who knew only a few letter names and who were unable to read words out of context found the visual cues easier to learn. The children who knew some letters but were as yet unable to read, found it easier to learn the phonetic cues. Ehri suggests that this is clear evidence that even at this very early stage of reading children are able to make use of phonetic information and use this to form associations between printed cues and spoken words. However, there is a problem of interpretation with this study. It is possible to argue that the children learned the phonetic cues more easily not because of the phonological information they contained but because they were more similar visually to the target word than the visual cue, although the visual cue was more distinctive. The letters in the phonetic cue were often the same letters as those in the target word.

The final stage in Ehri's model involves 'phonemic map reading'. This refers to the process of reading sight words by setting up connections in memory between all of the letters in a word and the phonemes in the word's pronunciation. This is in contrast to children in an earlier phase who set up partial phonetic connections. The reader in this phase is also able to recode words, analysing words at the phonemic rather than phonetic level. Ehri & Wilce (1987a) created groups of readers in phases 2 and 3 of their model of reading development by giving some children training in recoding words and some isolated sound-letter practice. The groups were then tested to assess their ability to learn to read and spell a set of words. The subjects were given up to 7 trials to learn to read 15 similarly spelled words. The phase 3 group learned to read almost all of the words whereas the phase 2 readers learnt only a few words. It was suggested that the phonemic readers were better able to learn to read the words because they were able to recode them and because their more complete connections prevented their connections being confused with the connections established for other words. Error analysis suggested that the cue readers confused words on the basis of partial letter cues, primarily initial letters. The subjects were then tested on their memory for the spellings they had learnt to read. Phase 3 readers were able to recall more correct letters and more correct spellings than the phase 2 readers. The phonetic cue readers were able to recall as many initial and final letters as the phase 3 readers, possibly because these were the letters used in forming connections in the reading task. Ehri proposes that the transition between the phases is gradual and dependent on the reader acquiring various phonological skills.

Rack, Hulme, Snowling and Wightman (1994) taught children to associate three letter cues with spoken words . Two sets of cue were used, those which were phonetically similar, and those which were phonetically dissimilar to the target. So, for example, the target word 'beaver' was represented by the phonetic cue 'bfr' and the control cue 'bzr'. The phonetic cues contained a single letter whose phoneme differed from a phoneme in the target word by a single feature of voicing, the equivalent letter in the control cues always differed in place of articulation, and sometimes also differed in voicing, from the central phoneme in the target word. Eighteen children with a mean age of 5 years 6 months took part in the experiment. Most of the children knew well over half of the letters of the alphabet but their poor performance on a nonword reading test indicated that they were not yet able to decode. The children were taught 24 words in 3 blocks of 8 over 3 consecutive days. They found that there was a significant difference in the children's performance with the two types of cue. Children found it easier to learn phonetic cues than control cues. It was found that this effect was strongest when the altered letter was placed in the middle position, that is when the first and last letter of the cue remained the same as the target word, than when the altered letter was at the beginning of the cue. This finding confirms that the beginning readers were able to use the phonetic information contained within the cue and were not depending on visual strategies. Rack et al., on the basis of their results propose a 'direct mapping mechanism' by which children learn to read. Learning, in these early stages is, they argue, dependent not on the explicit awareness of letter sounds and applying this sequentially but rather, "involves the automatic activation of (possibly partial) information about words' pronunciations from cues present in the printed words' letter sounds or letter names" (p.44). In this way the children are using phonological information from a very early stage and much earlier than suggested by the stage theories of Marsh and Frith. An important feature of the Rack et al. study is that it demonstrates that children are able to access and use much smaller units of phonology in learning the cues than they are consciously aware of. This provides evidence for the distinction between phonological awareness and the underlying representations of phonology, as discussed in Section 1.4.3.

The direct mapping mechanism has also been demonstrated in experiments in which children are seen to infer sublexical relationships from print and use this information in learning to read novel items. Thompson, Cottrell & Fletcher-Flinn (1996) studied a group of children in the early stages of reading development. They found that these children were able to infer relationships between the phonological and orthographic components common to several words and use this knowledge to read novel items. This supports Ehri's model of reading development and the findings of Rack et al. in showing that children are able to use these stored letter-sound associations without awaiting the development of explicit decoding skills or the acquisition of the 'alphabetic principle' (Byrne & Fielding-Barnsley, 1989).

### 1.6.3. The Role of Phonological Skills in Models of Reading Development

The stage models reviewed so far have a clear role for phonological skills in the sense that they are clearly important to children's reading but, with the exception of Ehri's model they do not specify the mechanism by which the changes occur. Frith suggests that children learn grapheme-phoneme relations through learning to spell. In Ehri's model phonetic cue reading occurs as a result of learning letter-sound relations which lead to the formation of visual-phonological connections. However, these explanations of how change occurs are somewhat vague and in this sense stage models are more descriptive than explanatory.

Seymour (1994) attempted to provide an information-processing framework in order to specify the mechanisms of change more directly. In his 'dual foundation' model Seymour suggests that the orthographic system is the result of the merger of earlier systems. There are, he argues, four categories of cognitive processes, orthographic, phonological, logographic and alphabetic. The orthographic system in his model takes the form of a single structure which is seen as a framework or 'scaffolding'. This orthographic system forms a gradually developing core made up of consonants and short vowels, this core then expands to include more complex forms. He suggests that the development of the orthographic system is dependent on letter-sound knowledge, the logographic lexicon and the acquisition of phonological awareness. A logographic system is transformed into an orthographic framework when the child becomes able to segment words. The logographic phase has the important function of acting as a form of storage of more or less complete representations of words which can be consulted when constructing the orthographic framework. Seymour argues that transformation into the orthographic phase might depend on phonological awareness of segmentation, possibly segmentation into onset-rime divisions. This would explain the association between onset and rime and reading. Simple alphabetic knowledge is reorganised into an orthographic system, from a system of lists of associations applied sequentially to a word to the basis of the orthographic framework. This transformation is dependent on phonological awareness of linguistic distinctions between consonants and vowels, and positional distinctions between initial and terminal consonants. These simple linguistic distinctions form the core orthographic system which gradually evolves and incorporates more complex forms such as consonant clusters and long vowels. The orthographic lexicon then develops from a merger of previous systems, an alphabetic knowledge of letter-sound associations, structures represented in the logographic lexicon, and the acquisition of phonological awareness.

The model outlined by Seymour has an advantage over traditional stage models in that it attempts to offer an explanation of the nature and causes of change between the different stages. It also offers a more interactive approach than traditional stage models in suggesting a reciprocal developmental relationship between phonological and orthographic knowledge.

### 1.6.4. Connectionist Models of Reading Development

Connectionist models are one type of computational model of human cognitive processes. These models consist of many simple processing units with activation passed between units according to the strength of connections or weights joining them. Connectionist systems, or neural networks, it has been argued, are compatible with the computational nature of the human brain. These networks can be trained to show many of the behavioural characteristics of human brain and to this extent can offer a valuable insight into some of the processes that might underlie human learning.

Connectionist models are built on the assumption that learning progresses by encoding relationships between input and output patterns. The models attribute higher order knowledge to associations among simpler parts. In this way the models challenge some of the central assumptions of traditional models of cognitive behaviour in which learning is viewed as propositional and rule based. The models demonstrate that rule-like behaviour can be simulated through the learning of regularities or associations in a given environment without explicit incorporation of rules into the system.

The models consist of individual, sub symbolic computing units that are heavily interconnected. By linking these units, e.g. input and output units to one another via hidden 'mediating' units rule like behaviour can be imitated in the learning that takes place. These emerging rule-like properties associations are dependent not on the units themselves but on the way in which they have become interconnected as a result of learning. The links between the units come to embody a statistical relationship. The networks are interconnected with connections of various strengths. It is the adjustment of connection strengths in proportion to the discrepancy between an actual pattern of activity and the desired pattern that brings about learning. The network comes to learn the statistical properties of associations between input and output units. Because the models gradually learn the statistical regularities of a system they can be useful in thinking about developmental progression in human learning.

The first and most influential connectionist model of reading is the Seidenberg and McClelland (1989) model. This model includes three components, input or orthographic units, output or phonological units and hidden units which connect the orthographic and phonological units. The orthographic component codes visual properties of words, the phonological component codes the phonological properties and the hidden units mediate between the two sets of representational units. The model is designed to receive orthographic input of printed words presented in isolation and to encode knowledge about the correspondence between these orthographic inputs and their pronunciations.

In total this model employed 400 orthographic units, 200 hidden units and 460 phonological units. Words are decomposed and represented as triples of adjacent letters, for example, 'make' is decomposed to -MA, MAK, AKE and KE-, where '-' represents the beginning or ending of a word. Each orthographic unit comprises three slots and there are ten possible characters that can fill each slot, with the constraint that the '-' character cannot fill the middle slot. In this way each orthographic unit encodes one thousand character triples. Similarly, the phoneme string is treated as a set of character triples, for example /mak/, the phoneme string for 'make' is decomposed to -ma, mak, ak- and each phonetic unit represents a triple of phonetic features. Hence in this model each triple of phonemes is encoded as a pattern of activity distributed over a set of units representing triples phonetic features, such as consonant or vowel, voicing, and so on.

Before 'training' full connectivity exists between the orthographic units and the hidden units and the hidden units and the phonological units. The connections between the units carry weights which control the spread of activation across the units. Initially the weights on all connections are initialised with small random values between -0.5 and +0.5. The model is then 'trained'. Words are presented to the model, with the frequency of a word's presentation being proportioned to the word's frequency in the English language. Words presented are encoded by the orthographic units resulting in a specific pattern of activation. Activation is then propagated forwards to the hidden units and forwards again from the hidden units to the phonological units. As soon as activation is received at the hidden units, feedback from the hidden units to the orthographic units occurs. The pattern of activation across the hidden units combined with the weights on the links between the hidden units and the orthographic units is crucial. The feedback is compared to the original input and this discrepancy is used to guide changes in the weights on the connections between the hidden units and the orthographic units. This process is then repeated for the phonological units. In this way the model is trained to associate input patterns on the orthographic units with the output patterns on the phonological units by adjusting the strength of the connections between units.

The model does not use rules to relate individual sounds to individual letters but learns the mapping or statistical relations between a set of input patterns and a set of output patterns. In this way such networks challenge traditional models of reading because they do not require dual routes but rely on a single route from orthography to phonology.

The performance of the model on different tasks was then compared to human performance by presenting the words to the model and computing error scores. The error scores are then taken as an index of performance. The model, according to Seidenberg and McClelland simulates human performance on many word-processing tasks, in showing a frequency effect and a regularity effect and a frequency by regularity interaction. Behavioural data have demonstrated frequency effects in word recognition such that high-frequency words are recognised more rapidly than low-frequency words (Balota & Chumbley 1985). Furthermore, regularity effects (i.e. recognising regular words more rapidly than irregular, or exception, words) have also been shown to interact with these frequency effects. Faster latencies are found for regular words, compared to exception words, with low-frequency words but not with high-frequency words (Waters & Seidenberg 1985). The fact that the Seidenberg and McClelland model is able to simulate these effects provides considerable support for the model. It is also claimed that the model shows impairments in performance that are not dissimilar to those found in dyslexia when it is 'lesioned' (Seidenberg 1992, 1993). Seidenberg & McClelland attempt to simulate some of the effects seen in developmental dyslexia by training the model after eliminating half its hidden units. With fewer hidden units the model shows generally poorer performance and is particularly impaired in the recognition of irregular and exception. It is suggested that although with fewer units the model can learn generalisations about regular words, it does not have the capacity to encode enough word-specific information to enable effective generalisation to exception words.

Regularity effects were attributed in dual-route models to the fact that a separate phonological route exists and is required to recode irregular words which takes longer than reading regular words. However, this model demonstrates that a regularity effect emerges within this single route. This has important implications for dual-route models and stage models. The notion that a separate early stage exists in which the phonological route is not required seems untenable both in the light of the evidence cited by Ehri (1987, 1992) discussed earlier and in the light of these neural networks which suggest that only a single route is necessary. Indeed, Ehri's model of reading development, discussed in Section 1.6.2., can be related to the Seidenberg and McClelland model. Like Ehri's model, learning to read in this model is dependent on the establishment of connections between orthographic and phonological units. Similarly, Rack et al.'s notion of 'direct mapping' can usefully be related to the processes involved in the computer establishing these connections. The featurally based representations of phonology employed by the Seidenberg and

McClelland model provide a way of thinking about the Rack et al. findings. A system that employs such representations would be expected to be sensitive to similarities between sounds, as children in the Rack et al. study were.

### 1.6.5. Problems with the Seidenberg and McClelland model

Connectionist models offer a powerful way of studying human cognition. However, a number of criticisms have been made of the model, particularly regarding its potential to model children's reading. Hulme, Quinlan, Bolt and Snowling (1995) suggest that the Seidenberg and McClelland model is not a psychologically realistic description of the processes involved in children learning to read. They argue that the model ignores the evidence linking phonological skills to reading development. There is good evidence to suggest that children come to the task of learning to read with highly developed phonological representations, furthermore phonological awareness tasks which tap these representations are good predictors of children's reading. Hulme et al. attempted to build a model specifying the phonemes used in the model in terms of a listing of their articulatory features. This included an organised phoneme map which aimed to capture the articulatory similarities between different phonemes. They found that the model learned to pronounce 96% of the words on which it had been trained and showed correct generalisation to 83% of a subset of single-syllable words on which it had not been trained. It would seem that the pre-existing phonological structure developed in their model has important implications for its ability to learn the relationships between words' spelling and their pronunciations.

Coltheart, Curtis, Atkins and Haller (1993) make a number of criticisms of the Seidenberg and McClelland (1989) model, particularly of its claim to refute the need for two different procedures for reading. Firstly, they argue that there are problems with assessing the correctness of a response in the model. Correctness is rated in the model using a BEATENBY procedure. According to this criterion a response is judged incorrect if the correct target is beaten by any incorrect alternative. However, Coltheart et al. (1993) argue that this does not guarantee that the computed response would not be beaten by any incorrect potential output. It is possible that there might be a potential output that fits the computed output well but it is not in the list of potential outputs that the beatenby procedure generates.

A further criticism of the Seidenberg and McClelland model is it's poor performance with nonwords. Besner, Twilley, McCann and Seergobin (1990) analysed the performance data of the Seidenberg and McClelland model using the BEATENBY procedure and found that performance was 59% and 51% with two sets of nonwords. Given that human subjects are able to read 94% and 89% of these words this represents a poor simulation of human performance. This is clearly important because Seidenberg & McClelland argue that a single route is able to read all kinds of words whereas dual-route theorists argue that nonwords are read using a separate grapheme-phoneme correspondence route. Coltheart et al. (1993) suggest then that two routes are necessary for successful reading and therefore models using two routes will perform at a higher level than those using just one route. Coltheart et al. (1993) propose their own computational model, the dual-route cascaded (DRC) model in which the algorithm learns, through exposure, the grapheme-phoneme rules embodied in the training set and is then able to apply these rules to novel letter strings. The algorithm learns by inferring all the grapheme-phoneme conversion rules that describe the relationship between the word's spelling and its pronunciation. The model then discards all but the most frequent rule within each set of conflicting rules, frequency values being set by the user. Activation at all levels (graphemic, phonemic and semantic) occurs in a cascaded manner, and are activated through excitatory and inhibitory processes. Grapheme-phoneme conversion works in parallel with a lexical look-up process in a cascading rather than in a thresholded manner. The model is able to correctly pronounce 78% of the words and 98% of the nonwords presented to it. However, it is possible to criticise the model on the grounds that its success is dependent on a number of assumptions built into the training procedure about the relationships between grapheme-phoneme correspondences. In contrast the connectionist models discussed are able to learn on the basis of the ordered triples of letters and phonemic features alone without further information about their correspondences, suggesting that rule-based learning may not be necessary.

A more recent connectionist model based on the earlier Seidenberg and McClelland model addresses some of the criticisms raised by Coltheart et al. (1993). Plaut, McClelland, Seidenberg and Patterson (1993) suggest that there are two main reasons for the poor nonword performance of the Seidenberg and McClelland (1989) model: the limited size of the training corpus and the use of Wickelfeatures to represent phonology. The Plaut et al. (1993) model changes the nature of the representations of phonology and orthography and finds performance is improved. A problem with the representation of phonology in the earlier model is that the features of phonemes are not bound with each other but only with features of neighbouring phonemes. It is possible, therefore that the surrounding context introduces inappropriate features so that when knowledge is learnt in one context it is not well generalised to other contexts. When the nature of these representations is changed so that instead of being context dependent they are dependent on phonotactic constraints, the performance of the model is improved. Nonword performance on the Plaut et al. model is much improved. On a set of nonwords (Glushko 1979) the network read 97.7% of the consistent nonwords correctly, compared to human performance of 93.8%, and read 72.1% of inconsistent nonwords words correctly, compared to 78.3%. The fact that this model, using a single route, had achieved such high levels of performance with nonword directly refutes the claims of dual-route theorists. The Seidenberg and McClelland model had poor representations which limited nonword performance, when these representations are improved so too is the overall performance of the model.

### 1.6.6. Summary

In summary, it is possible to argue that the traditional stage models, although useful as descriptions of behaviour, are limited in their explanation of how the mechanisms that underlie reading work. Firstly, the stage models of Frith and Marsh are built on the premise of a dual-route approach, a notion which has come under increasing criticism in the past 10 years both as a result of theoretical advances and empirical work. Secondly, there is evidence which questions the way in which some models conceptualise the role of phonology in reading development. It would seem that children are able to access and use phonological information at a much earlier age than assumed by some models. Clearly, the information they are accessing at this point is activated without explicit awareness of it. Connectionist models offer a way of conceptualising these mechanisms and suggest that reading skills develop as the child learns patterns of associations between input and output. These associations can be captured within a sub symbolic framework in which connections are made and modified between representations of the orthographic and phonological forms of words. These computer models are still at the early stages of development and have a number of problems with regards to modelling the child learning to read. Nevertheless, they are a considerable step forward in providing a useful framework for understanding some of the processes involved in reading development.

## 1.7. The Role of Semantics in Reading Development

### 1.7.1. Introduction

Although many models have focused on the role of phonological skills in reading, it is clear that reading is dependent on more than the ability to decode words and map letters onto sounds. Meaning also plays an important role in reading and indeed the extraction of meaning from text might be considered the primary purpose of reading. While the need for semantics might be obvious when discussing reading comprehension, it is also the case that semantic factors have a role to play in single word recognition.

Two semantic influences on word recognition will be considered. Firstly, the influence of context on word recognition will be examined, that is, the extent to which readers are able to use context to facilitate word recognition. Secondly, the influence of the semantic properties of individual words will be considered. That is, the extent to which semantic properties will influence the ease with which a word is processed and read.

### 1.7.2. The Separability of Decoding and Comprehension

It is clear that both semantics and phonology will have a role to play in successful reading. These two properties of language are commonly viewed as distinct skills which interact in the reading process. Gough and Tunmer (1986) propose a simple model of reading development in which reading is viewed as the product of decoding and comprehension (reading = decoding x listening comprehension). They argue:

"Decoding is clearly not sufficient for reading. But at the same time we argue that decoding is necessary for reading, for if print cannot be translated into language, then it cannot be understood." (p.7).

Some evidence for this model comes from a longitudinal study done by Hoover & Gough (1990) who found that for children in Grades 1 to 4 the product of listening comprehension and phonological recoding accounted for a significant proportion of variance in reading comprehension. This model predicts that reading problems can arise from an inability to decode, or to comprehend language, or both. It is possible that children could possess adequate decoding skills but have problems with reading comprehension and similarly that children could have poor decoding skills but good comprehension skills. A third group of children is also suggested, those with both poor decoding and poor comprehension skills, referred to as "garden variety" poor readers. Furthermore, it was also found that decoding accounted for more variance in reading in the lower grades, suggesting that at this earlier stage of reading development the ability to decode words is of primary importance.

### 1.7.3. Contextual facilitation

Researchers have sought to investigate the extent to which readers are able to use context to facilitate word recognition. Many have done this using a priming paradigm where a target word is preceded by a context (either a single word, a sentence or a paragraph) and the reader is asked to name the word or make a lexical decision response. To the extent to which word recognition is improved with the presence of a context, contextual facilitation can be said to have taken place. A second method of examining the influence of context has been to consider the types of errors subjects make. If the errors made are contextually appropriate this may be one indication that readers rely on context in word recognition.

#### 1.7.3.1. Comparing good and poor readers' use of context

It has been suggested by some that skilled readers are better at using context in a predictive way than less skilled readers (Goodman, 1973; Smith, 1971, 1978). According to these theorists, reading is viewed as a 'psycholinguistic guessing game' in which syntactic and semantic cues are used to predict words in the text. According to this view the ability to predict from text in this manner, using general language skills is more important than decoding ability. Therefore, the fact that skilled readers are better at predicting from the context is what makes them skilled readers. There is, it would seem, little empirical evidence to support this claim. Although there is evidence that better readers are able to use contextual information to facilitate comprehension (Stanovich and Cunningham, 1991), there is little evidence that good readers rely more on context than poor readers for word recognition. Indeed, there is good evidence from both discrete trial reaction time studies and error analysis studies that not only do poor readers use context, but that they often show larger context effects than the better readers. Whaley and Kibby (1981) analysed the errors of 98 beginning readers reading a short passage. They found that at the end of the first year in school the skilled readers were more reliant on decoding skills than the context, that is the skilled readers were not using the context to aid word recognition more than the less skilled readers. Similar results have been found elsewhere (e.g. Biemiller, 1979; Perfetti and Roth, 1981)

Leu, DeGroff and Simons (1986) examined the errors made by 36 first-grade readers when reading a highly predictable story text, such as those used in school reading schemes. Leu et al. replaced a number of words in the text with target words that were semantically and syntactically consistent with sentence context but inconsistent with the repetitive sentence context of the predictable text. The use of context in word recognition was examined by looking at the children's' response to these 'target word locations'. Two types of response were considered; responses which were 'discourse appropriate substitutions' (i.e., the word that had originally appeared at that place in the story) and responses which were graphically expected responses (i.e., the target word that had been altered). The frequency of discourse appropriate substitutions was considered as a measure of context use. The results indicated a negative association between reading achievement and the frequency of discourse based substitutions. Poorer readers were shown to produce more discourse appropriate words, suggesting the use of contextual information at the expense of other information. Conversely, good readers were shown to read the target word as it appeared.

Similar effects are seen when a priming paradigm is used. Pring and Snowling (1986) looked at young children's performance with nonwords that are pronounced as words, i.e. pseudohomophones (e.g. burd) to see whether they would use context to facilitate performance. The pseudohomophones were presented in one of three conditions, a semantically related condition (e.g., doctor-nirse), a semantically unrelated condition (doctor-nite), and a neutral condition (xxx-nite). The performance of good and poor readers was compared on this task. When the non-words were preceded by semantically related words, poor readers were faster and more accurate reading them than in the unrelated and control condition. Good readers also benefited from the context, but to a significantly lesser extent.

Stanovich, West and Feeman (1981) found a similar pattern of results when the priming context was a sentence rather than a single word. When the target words were preceded by a sentence context they were read significantly faster and more accurately than when presented in isolation. This contextual facilitation was found to be greater for a set of difficult words (in terms of ease of decoding) than it was for a set of easier words. Furthermore, the less skilled, younger readers were shown to be more influenced by sentence context than the older, more skilled readers.

In summary, the finding that poor readers are as dependent, if not more dependent, on contextual information in word recognition has been replicated across a large number of studies employing error analysis and priming paradigms (Simpson

& Foster, 1986; Stanovich, 1980, 1986; Perfetti, 1985; Simons & Leu, 1987). These findings contradict the theories of Goodman (1973) and Smith (1971, 1979) who predicted that good readers would use context more than poor readers in word recognition. It would seem that the reverse is the case. The superior decoding skills of the good readers mean that they do not need to depend on contextual information.

#### 1.7.3.2 The Developmental Use of Context

The studies reviewed in the above sections suggest that the effects of context on word recognition decrease as reading skill improves. A number of longitudinal studies have confirmed this from a developmental stance (Stanovich, West & Feeman, 1981; Stanovich, Cunningham & Feeman, 1984b). However, there is also evidence that these effects of context can be found in the first year of learning to read. Error analysis of children's reading during this first year has also shown that 70% to 95% of initial errors are contextually appropriate (Biemillar, 1970, 1979).

If the effects of context on word recognition decrease as reading skill increases, contextual facilitation effects may be considered a function of decoding skill. Perfetti (1985) argued that when the level of decoding between good and poor readers is equated they will show context effects of a similar magnitude. Using a paradigm similar to that used by Simons et al. (1983), Perfetti showed that when print is degraded so that the word recognition speed of a good reader is as slow as that for a less skilled reader the good reader shows context effects of the same size.

Stanovich, Cunningham & Feeman (1984b) did a longitudinal study looking at the effects of context on word recognition in beginning reading. The results indicated that skilled readers did show more contextual facilitation than less skilled readers at the beginning of the year. However, when, a year later, the less skilled readers had reached a similar level of context free decoding as the more skilled readers, they were equally able to benefit from context. These findings provide support for the notion that contextual facilitation is a function of decoding skill.

However, as Stanovich (1986) suggests, this is only the case when the preceding context is adequately processed by both the skilled and less skilled readers. If the preceding context becomes too difficult for the poor reader, he or she will be unable to use the context to facilitate word recognition. In such circumstances poor readers would not show greater contextual facilitation effects than good readers.

It would seem that beginning readers need first to achieve some level of context free word recognition before they are able to benefit from context. In terms of contextual facilitation, the role of semantics is limited to a point in development when some level of phonological decoding skill has developed. Thus, although phonological skills are shown to interact with semantic skills and indeed influence the development of one another, in the early stages of reading development, phonological skills may be primary.

#### 1.7.3.3. The Relationship between Language Skills and Contextual facilitation

An important question is what kind of language skills are important in predicting a reader's use of context. Rego and Bryant (1993) examined the performance of 57 five-year-olds on a range of phonological and semantic tasks. The aim was to consider which of these language tasks would predict later performance on an invented spelling task (considered to be a phonological outcome measure) and on a contextual facilitation task (considered to be a semantic outcome measure). They found that performance in phoneme oddity and phoneme tapping tasks at time one successfully predicted performance in the invented spelling task at time two, however, performance on these two tasks did not predict the later performance on the contextual facilitation task. Similarly, performance on a cloze task, a sentence anagram and a sentence completion task predicted later contextual facilitation but not later spelling. These results suggest that semantic skills and phonological skills may make independent contributions to skilled reading.

Similar results were found by Nation and Snowling (1998) who found that scores in a contextual facilitation task (see below) correlated with a composite score from a set of semantic tasks (semantic production and synonym judgement) but did not correlate with a composite phonological score. It would seem that children's syntactic awareness and semantic skills are related to children's ability to use context. Successful reading is clearly dependent on skills other than phonological skills.

### 1.7.4. Interactive-Compensatory Models

One way of conceptualising the greater contextual facilitation effects shown by poor readers has been to suggest that context is used in a compensatory way. It has been suggested that difficulties with phonological skills can be compensated for by good semantic skills (Stanovich, 1980; Perfetti & Roth, 1981). According to these models, bottom-up processes (sensory input, letter knowledge, decoding skills) and top-down processes (semantic information and knowledge) operate in tandem in reading and therefore semantic, syntactic, phonological and orthographic information is processed simultaneously. A prediction of this model would be that individuals with an impaired phonological system would show a greater advantage of context than readers with intact phonological systems. Clearly, the studies reviewed above provide support for this hypothesis. Further support is provided by a number of studies which compare the contextual facilitation of dyslexic readers with normal controls.

Ben-Dror, Pollatsek and Scarpati (1991) compared the contextual facilitation of college age dyslexics with chronological and reading-age matched controls. The results of this study indicated that the dyslexic students showed more contextual facilitation than the chronological-age matched controls and as much as the reading-age controls. In terms of the interactive-compensatory model the slower word recognition of the dyslexic students meant that more time was available for top down processes to operate and thus additional facilitation from context was provided.

Nation and Snowling (1998) compared the contextual facilitation of dyslexic readers with normal readers and with a group of children with poor comprehension but normal decoding. All three groups were presented with single words on a computer screen which were either preceded by a spoken sentence which would prime word recognition or by a neutral sentence that would not prime word recognition. The children were asked to name the words with and without context in order to assess the amount of facilitation the context provided. The amount of benefit derived from the context was measured using a ratio equation. The ratio score is a measure of improvement relative to the maximum amount of improvement possible, based on performance with the words presented in isolation. They found that the dyslexics showed larger improvements than both the normal readers and the poor comprehenders in terms of both speed and accuracy. Further, the normal readers showed greater facilitation effects than the poor comprehenders. These results again provide support for the idea that children with phonological problems, i.e., dyslexics are able to use contextual cues to support word recognition, and hence to compensate for their weak phonological skills. The fact that the children with reading comprehension difficulties showed the least contextual facilitation demonstrates that good phonological skills are not enough to develop competent reading skills. These children have good phonological skills, however, their inability to use context effectively may limit the development of their word recognition. Nation and Snowling suggest that when a word is presented in context a combination of partial phonological information and an awareness of the possible constraints of the context provides the normal reader with more cues to aid successful reading. In this way context may provide a form of self-teaching mechanism and hence those that are sensitive to context will benefit from this mechanism most.

### 1.7.5. The Division of Labour between Phonology and Semantics

It is also possible to conceptualise this interaction between phonological information and contextual cues in terms of a division of labour. Plaut, McClelland, Seidenberg and Patterson (1996) propose a connectionist model which incorporates a contribution from both phonological and semantic pathways.

Plaut et al. (1996) attempted to incorporate a contribution from semantics into their simulation of reading behaviour. The model is based on the same principles as the Seidenberg and McClelland model (1989) described in Section 1.6.4. They do this by training the phonological pathway in the presence of some amount of "appropriate external input to the phoneme units", this they argue will provide additional input to the phoneme units and will push them towards their correct activations. They found that, in comparison to a model trained without additional support from semantics, learning was improved. As the semantic pathway increased in strength the accuracy of the combined network improved. As learning continues they found that a redistribution of labour between the phonological and the semantic pathway occurs. As the contribution from the semantic pathway increased the pressure to continue to learn using the phonological pathway lessens as some word types, in particular exception words, are more economically processed via the semantic pathway. This redistribution of labour leads to the weights in the phonological pathway getting smaller as the amount of error is reduced due to the effects of the semantic pathway. The phonological pathway becomes more specialised in pronouncing consistent spelling sound correspondences. It is important to note that even with extended training the phonological pathway was still able to read some exception words, particularly those of high-frequency. This is different from the sublexical procedure in a traditional dual-route theory which can only read regular words and not exception words.

The interaction between phonological and semantic skills is, therefore, characterised as a 'division of labour' between a phonological process that deals with mappings between orthographic and phonological representations and an interacting semantic process that deals with mappings between orthographic, semantic, and phonological representations. In terms of the development of reading Plaut et al.

argue that in the early stages of reading the development of the phonological pathway is primary with the establishment of connections between orthography and phonology via a set of hidden units. This is consistent with the evidence presented in Section 1.7.3.2. suggesting that children require a degree of context free decoding before they are able to benefit from context. This model also suggests that as learning continues semantic factors become increasingly important for learning to read.

## 1.8. The Role of Semantics in Single Word Learning

A common view, as discussed above, is that a printed word must first be mapped onto its phonological representation before its meaning can be accessed and any benefits of context can be reaped. However, it is also possible that meaning-level variables (e.g. semantic class) participate in word recognition processes when words are presented in isolated or neutral contexts. A number of studies have considered the extent to which the semantic qualities of an individual word can influence the ease with which it is processed and read. A commonly used paradigm has been to look at the influence of the semantic qualities of a word, most usually the concreteness or imageability of a word, on word learning, word recognition or on lexical processing. Concreteness and imageability are often taken as the semantic variables because of evidence of their effects on single word reading and their role in the acquired reading disorders, as discussed below.

### 1.8.1. The Influence of Semantic Variables in Studies of Word Recognition

A semantic variable that has been shown to influence word recognition and lexical processing is imageability. Imageability refers to the extent to which the meaning of a word evokes a mental image. Imageability is often confused with concreteness, concrete words are those with tangible referents and are also more imageable than abstract words. In many of the studies to be discussed here imageability and concreteness have been used interchangeably, that is concreteness has been confounded with imageability and vice versa. Although there are some important differences between these two variables, for example, it is possible for a word to be both highly imageable and abstract, it is also the case that they are very highly correlated with one another. For the purposes of this discussion the distinction between concreteness and imageability are unimportant to the extent to which both represent possible meaning level influences in word recognition.

Imageability, or concreteness has been shown to influence word recognition (Strain, Patterson & Seidenberg, 1995), lexical decision (Day 1977, James 1975), and comprehension (Schwanenflugel & Shoben 1983) in skilled adult readers. Furthermore, studies of the acquired dyslexias have shown that deep dyslexics have impaired naming ability for abstract as compared to concrete words (Coltheart, Patterson & Marshall 1980; Shallice & Warrington, 1975, 1980).

James (1975) showed that subjects were faster to decide whether letter strings were words or not when the target word was concrete than when it was abstract. He found an interaction between frequency and concreteness which indicated that low and medium-frequency abstract words produced slower response latencies than concrete words at the same levels whereas there was no impact of concreteness for high-frequency words.

Concreteness or imageability has also been shown to influence word recognition in skilled readers, such that concrete words are read faster and more accurately than abstract words. Strain et al. (1995) have shown that this concreteness effect in naming is also modified by frequency with imageability effects being found for low-frequency exception words. This interaction will be examined in more depth in Section 1.9., for now it is enough to note that even skilled adult readers, in some circumstances will show a processing preference for concrete over abstract words.

Concreteness has also been shown to influence comprehension. Schwanenflugel and Shoben (1983) showed that sentence comprehension is faster for sentences composed of concrete words than for sentences composed of abstract words. They also reported that reading and lexical decision times were faster when abstract sentences and words were preceded by paragraph and sentence contexts, as compared with no-context conditions. However, context was not shown to help the concrete words. They suggest that the cognitive context of the concrete words is normally adequate and therefore they do not benefit from extra context.

In summary, the studies reported above suggest that even skilled readers are influenced by the semantic variable of concreteness or imageability. It is also the case that this influence is more pronounced in particular circumstances, in particular when the word is of low-frequency or is very irregular.

### 1.8.2. The Effect of Semantics on Word Learning and the Acquisition of a Sight Vocabulary

A number of studies have examined whether concrete words, or words high in imageability, are acquired more easily than abstract or low-imageability words as part of a child's sight vocabulary. Richmond and McNinch (1977) examined the performance of two groups of 6-year-old children differing in their 'reading readiness', as measured by the Metropolitan Reading Readiness Tests, form A (Hildreth, Griffiths, and McGauvan 1964). There were 9 children in the high reading readiness and 13 children in the low reading readiness group. Eight four-letter words were selected from the Dale List of 769 easy words, controlling for frequency, configuration, initial and last letters. The eight items were; *calf, park, four, dust* in the concrete set and *with, good, been* and *luck* in the abstract set. Although the means differed no significant concreteness effect was found and the effect of reading readiness group and the group x word type interaction were not significant. However, the sample size and number of words used is limited and therefore it remains difficult to draw many conclusions from these results. Furthermore, the word forms in the two word groups differed, with the concrete words all being nouns and the abstract words including verbs. Concreteness was, therefore, confounded with word form or grammatical class.

Kiraly and Firlong (1974) taught kindergarten children 2 abstract (*make* and *good*) and 2 concrete words (*fire* and *boat*). Eighty children, 40 with high reading readiness (as measured by the Gates-MacGintie Reading Readiness Skills Test 1968) and 40 with low reading readiness completed the task. Ten learning trials and 10 test trials were given. It was found that the high reading readiness children performed significantly better than low reading readiness group, learning significantly more words overall. It was also the case that concrete words were learned more easily than abstract words. No significant group x word type interaction was found. Although a concreteness effect was found, concreteness was again confounded with word form and again the number of words taught was limited to two per condition.

Yore & Ollila (1985) included more words in their study. Nine concrete and 9 abstract words, selected from Moe's Words of Highest Frequency (1973) were taught to 99 six-year-old children. The concrete words were all nouns and the abstract words were all non-nouns. Teachers taught whole classes of children the words, using flash cards. In the test trial the experimenter read the word and the children were required to circle the word from three options. Their results indicate that the children learned the concrete words 6.4% better than the abstract words. However, there are a number of factors which limit the findings of this study. Firstly, no pre-test of the words was given and therefore it is not possible to say whether more of the concrete words may have been known at the outset which could account for the difference between concrete and abstract words in the learning trials. Secondly, the words selected were not controlled for frequency or familiarity and it might therefore be possible to argue that either of these variables could have explained the differential learning rates for concrete and abstract words. Thirdly, concreteness was again confounded with word form and therefore grammatical class cannot be excluded as a possible explanation for any differences in learning.

A recent study has attempted to control for grammatical class in considering the effect of concreteness. McFalls, Schwanenflugel and Stahl (1996) examined the more long-term acquisition of words differing in concreteness. In this study the concrete and abstract words were part of a structured reading programme used in Grades One and Two. The acquisition of words in the reading programme was compared to the acquisition of concrete and abstract words not included in the programme. Forty six reading scheme words and 42 words which had not appeared in the scheme up to that point were included in the study. All the words tested had a noun sense and although some of the words also had a verb sense, there was no difference between the number of words that could be either a verb or a noun in the concrete and abstract sets.

Two tasks were included, a lexical decision task and a naming task. In the lexical decision task the children were instructed to decide whether a word or nonword was presented to them. A main effect of reading skill and word (scheme v.'s non-scheme) was found in the lexical decision task but there was no main effect of concreteness nor any significant interaction. Concreteness did not seem to have an effect on lexical processing speed in this study, this has alsobeen found in studies of adult subjects. Similarly, with regard to the speed of word recognition in the naming task there was a main effect of reading skill and a main effect of scheme but there was no main effect in reaction times for concrete words and no significant interactions. It would seem that if concreteness influences early word reading it does not influence the relative speed with which words are named. Although no effects for concreteness were found in the reaction time data the accuracy data suggest large concreteness effects. When accuracy in the lexical decision task was examined a main effect of reading skill and a main effect of scheme are again found but a concreteness effect also emerges. A significant interaction between Concreteness and Scheme indicates a concreteness effect for the words in the scheme and not for the words not yet encountered. A 3.1% difference in accuracy for the concrete and abstract words was found with the non-scheme words compared to a 15.7% difference for concrete and abstract words in the scheme. The same pattern of results was found in the naming task with main effects for scheme and reading ability and a concreteness effect for the scheme words but not for the non-scheme words. Although concreteness has a strong influence on the accuracy with which the words from the reading scheme are read there is also a strong influence of another semantic variable on the non-scheme words: context availability.

Context availability refers to the ease with which people report being able to retrieve associated information about a word. This was measured by asking people to rate how easy it is to think of a sentence for the word. When frequency and word length were partialled out the context availability ratings for these words correlated with accuracy in both the tasks. For these words the ease of being placed in a sentence has a strong influence on the ease with which the words are learnt in their free reading. Both imageability and context availability had an influence on the accuracy of reading words in the reading scheme. Thus, it would seem that the richness of the semantic representation of a word will influence the ease with which it is acquired. Although semantic information is seen to be important in early word recognition it is also important to note that it does not seem to affect the speed with which the words are read, McFalls et al. suggest:

"The findings of the present study suggest that a certain degree of connection between the orthographic, phonological and meaning connections within a mental representation of the written word must occur before meaning affects automized word reading." (p.247 )

In summary, it is clear from this study that semantics does have a part to play in the acquisition of a sight vocabulary and that this effect is something separate from any possible bias towards learning words from a particular grammatical class. It is also clear that this influence of semantics is happening from the earliest stages of reading development and that the semantic quality of a word will influence the acquisition of that word into the child's sight vocabulary. What remains uncertain, however, is how this semantic influence is best conceptualised and measured as is shown by the slightly different results obtained when measures of imageability and context availability are used. This issue of what exactly is being measured and why it should impact on word learning is considered in more detail in Section 1.10.

## 1.9. The interaction of phonology and semantics in single word reading

The connectionist model proposed by Plaut et al. provides a good framework for considering the possible interaction of phonology and semantics in single word reading. They suggest that the interaction between phonology and semantics may best be described as a division of labour between phonological processing based on mappings between the orthographic representations and phonological representations and semantic processing based on mappings between the orthographic, semantic, and phonological representations. As discussed in Section 1.7.5., the performance of their model improved considerably when it was trained with semantics. They found that in the early stages the model relied more on phonological processing but as the contribution of the semantic pathway increases the contribution of the phonological pathway decreases as weights on the connections in the phonological pathway decrease. As this happens the phonological pathway becomes increasingly specialised at pronouncing irregular or exception words.

This model suggests a number of testable hypotheses. Firstly, it leads to the suggestion that semantic factors will have a greater influence on word learning and word recognition where orthographic to phonological translation is difficult, e.g. where the word is a low-frequency, exception word. Secondly, it suggests that in subjects with either impaired phonological skills (e.g. dyslexics) or those with impaired semantic skills (e.g. hyperlexics) we might expect the influence of semantic or phonological variables respectively to be increased.

There is some evidence from lexical decision tasks that concreteness effects interact with frequency. James (1975) asked subjects to judge whether strings of letters were words or nonwords. He found that reaction times were faster for concrete than for abstract low-frequency nouns but found no concreteness effect for high-frequency nouns. DeGroot (1989) replicated this interaction between concreteness and word frequency in a lexical decision task which also required subjects to decide whether the letter strings were words or nonwords. However, this interaction was significant for the subject analysis but remained marginal for the item analysis. In a word naming task a small effect of imageability was observed, which was significant for the subject analysis but not for the item analysis. A small effect of frequency was found but there was no significant imageability by frequency interaction. DeGroot argues that the interaction between concreteness and frequency may only occur in lexical decision tasks and may not be important in word naming.

Strain, Patterson and Seidenberg (1995) suggest that semantic features may be modulated by other features of the words not manipulated by DeGroot and argue that when these features are included a significant frequency by imageability interaction may be found. In particular, Strain et al. consider the role of regularity in moderating semantic effects, arguing that semantic factors would be most likely to come into play when orthographic to phonological translation is most difficult, for example, in low-frequency exception words. In a series of studies they looked at word recognition in adults for four types of words; high-frequency exception words, low-frequency exception words, high-frequency regular words and high-frequency regular words. In a series of experiments they examined the latencies in word naming and the types of errors produced in response to the words. They hypothesised that imageability would interact with regularity so that low-frequency exception words would show the largest imageability effect. They frame this hypothesis in terms of connectionist models of reading and argue that regular words will be computed rapidly because, even if the word is low in frequency, the computation of its phonology will be supported by weights on connections established by other words sharing the same sound and spelling pattern. In contrast, the computation of orthographic to phonological translation is difficult for low-frequency exception words and therefore the influence of semantics should be greatest for these words.

One experiment in this study examined the performance of 40 participants on a word recognition task. The words were all low-frequency words, half were regular and half were exception words. Bigram frequency, word frequency, imageability, number of letters and initial phonemes were controlled for. Significant regularity and imageability effects were found as well as a significant regularity by imageability interaction, although this latter finding was only marginally significant in the item analysis (p=.06). It was shown that there was a significant difference between performance with high and low-imageability exception words, however, the corresponding comparison for regular words was not significant. The error analysis suggested a similar pattern: there were significantly more errors produced with the exception words, there were more errors with low-imageability words and there was a significant interaction between regularity and imageability. There was also a significant interaction between error type and imageability with significantly more regularization errors than any other error type being made for low-imageability words, conversely, there were a similar number of regularization and other errors in the high-imageability words. Although familiarity was not controlled for, ratings were collected after the experiment and no significant confound between imageability and familiarity was found. In summary, the findings from these studies suggest firstly, that semantic representations are activated in the process of word naming and secondly, that semantic representations makes the greatest contribution to the computation of pronunciation for low-frequency exception words.

### 1.9.1. Comparing the Processing of Good and Poor Readers

There is some evidence that good and poor readers may process linguistic stimuli in different ways. Waterman and Lewandowski (1993) use a task based on that used by Byrne and Shea (1979) to consider the phonological and semantic processing of good and poor readers. In this task a list of words is presented and the child has to say whether the word had previously been presented or not. A number of possible confusions were included; for the target word 'bag', a rhyme (rag), a rhyming control (dab), a semantically related word (sack) and a semantic control word (mess) were included. A nonword condition was also included with just a rhyme and rhyme control. Forty good readers and 40 poor readers at two age groups, 8-10 years old and 14-16 years old were included. In the nonword task all the groups made significantly more rhyme target errors than rhyme control errors, indicating that the poor readers were as susceptible to phonemic confusability as good readers. However, in the word condition the pattern of results was quite different. In this condition poor readers made fewer phonological errors and more semantic errors than rhyming errors for both age groups. Conversely, good readers made significantly more rhyming errors than semantic errors. This suggests that the processing of the poor readers was slightly different in that they relied more on semantic than phonological coding in the word task. The authors suggest that the poor phonological efficiency, as indicated by their performance on phonological awareness tasks, means that when a different means of coding is available they will rely more on this. However, when a different means of coding is not available, as in the nonword condition, the poor readers demonstrate a sensitivity to the phonological attributes of the words.

A similar hypothesis was tested by Vellutino and Scanlon (1985). They suggested that memory for abstract words is more dependent on linguistic coding ability than memory for concrete words. They argued that if this were the case then it could be hypothesised that poor readers would be less able to remember abstract words than good readers and that they would, therefore, show a greater concreteness effect than the good readers. Sixty children at two age levels, 7-8 years old and 11-12 years old were included. Poor readers were defined as those 2 or more years behind reading grade level in the older children and 1 or more year behind grade level in the younger children, good readers were reading at, or above grade level. Ten high-imageability words and 10 low-imageability words were included. Each child was given six trials, each of which consisted of a list presentation followed by twenty seconds in which the child counted and was then asked to recall the words.

They found that at both grade levels concrete words were recalled more easily than the abstract words. With the younger age group both groups of reader were close on concrete words but not on abstract words. For the older children the interaction between group and word type was not significant but there was a main effect of group which indicated that the poor readers performed worse on the concrete words and the abstract words. A second experiment was carried out in which the number of trials was increased and each subject this time took part in two sessions two weeks apart. When this was done, effectively making the task less difficult, the pattern of results remained the same. Furthermore, error analysis showed that although in the younger group the poor readers made more semantically related errors than phonological and orthographic errors than the good readers; in the older group the good readers made substantially more semantic errors than phonological errors and the poor readers made a similar proportion of structural errors as the good readers. The results suggest, then, that although the younger poor readers do perform less well in memory tasks with abstract words, which are arguably more dependent on linguistic coding than concrete words, this is not the case with the older poor readers who were considerably worse than the good readers at recalling both concrete and abstract words.

The authors suggest that lexical memory problems in older poor readers may reasonably be attributed to their semantic development, that is, as a result of their reading problems the older readers may have 'limited semantic elaboration'. They cite another study which provides some evidence for this idea. Vellutino, Scanlon and Tanzman (1985) showed that poor readers perform less well on recall of taxonomically related words. They found that differences at the sixth grade level appeared to be correlated primarily with group differences in semantic organisation ability whereas differences at the second grade level were correlated with differences in linguistic coding as well as semantic organisation ability. So, poor readers do seem to be "more attuned to the semantic than the phonological attributes of the word stimuli, while normal readers were more evenly attuned to both attributes" (p379) but this cannot be generalised to the older poor readers.

#### 1.9.1.1. Comparing Good and Poor Readers reading of Concrete and Abstract Words

Studies examining the differential effects of imageability on good and poor readers have tended to produce somewhat mixed results. It would seem reasonable to expect that imageability would have a different effect on good and poor readers. If dyslexic children show impaired decoding skills due to poor phonological skills then we might expect that they would benefit more from the semantic qualities of a word than children with good decoding skills. Considered in terms of a connectionist model such as that proposed by Plaut et al., word recognition is boosted by semantics most when orthographic to phonological translation is most difficult. This hypothesis is given support by the findings of Strain et al. (1995), as discussed above. Is it possible that for individuals whose phonological skills are impaired, word recognition will be more influenced by semantic activation than for normal readers with proficient phonological skills ? Clearly, this may also be conceptualised in terms of a traditional dual-route model of reading which proposes two independent routes to word recognition, a phonological route and a visual route. If one route is particularly impaired for the dyslexic readers, e.g. the phonological route, then perhaps this will increase reliance on the visual route, which may in turn be more influenced by the semantic qualities of the word. However, as discussed in Sections 1.6.2 and 1.6.4., there are considerable difficulties with dual-route models.

Jorm (1977) investigated the effect of word imagery, word length and word frequency on good and poor readers. A group of 24 good readers was compared with a group of 24 poor readers. The good readers had an average reading age 1 year 5 months in advance of their chronological age and the poor readers had a mean reading retardation of 3 years 2 months; both groups had the same mean IQ. The results indicated that while frequency was found to be an important influence on good and poor readers, imageability was found to influence poor readers only, with high-imageability words being easier to read than low-imageability words. Word length was found to have no effect on reading difficulty for either reading group. However, a serious criticism of this study is that the good readers are at ceiling or close to ceiling with all the word types. Therefore, it is possible that an imageability effect in the good readers is masked by these ceiling effects. As a result of this no firm conclusions about the differential effect of imageability can be made from this study.

Baddeley, Ellis, Miles & Lewis (1982) also found strong imageability effects on reading accuracy in a group of 15 twelve-year-old dyslexics, however, this imageability effect did not seem to be a specific feature of dyslexia but was also found in chronological- and reading-age matched control groups. The subjects were shown 20 high-imageability words and 20 low-imageability words; word length, frequency and rated concreteness was controlled for. All three reader groups made more errors with the low-imageability words than with the high-imageability words. Although the mean effect size is slightly higher for the dyslexic group (70, compared with 64 for the reading age controls and 20 for the chronological controls) this difference is not significant. These results are also in line with those studies reviewed in Sections 1.8.2 and 1.9 which suggest that even skilled readers may be affected by the imageability of a word. Nevertheless, the mean effect sizes do suggest a trend towards a greater imageability effect for the dyslexic readers.

Other studies comparing the performance of good and poor readers have found no influence of imageability at all. Klose, Schwartz and Brown (1983) compared good and poor readers on a lexical decision task and a naming task using 40 high and 40 low-imageability words controlled for concreteness, age of acquisition, length and frequency. Age of acquisition refers to the estimated (by adult ratings) age at which a word is acquired by children. Age of acquisition was included in this study in an attempt to investigate whether the imageability effects seen in previous studies were a function of the stage at which a word is acquired. In the lexical decision task subjects were shown the words on a computer screen and asked to judge whether the word was the same as the previous word shown. In a second task the subjects were asked to name the word and latencies were recorded. The teenage subjects were divided into good and poor readers on the basis of a reading comprehension task. The two groups of 11 subjects had mean reading scores indicating an average two year difference in reading age.

The results showed that performance in neither the lexical decision task nor in the naming task was affected by imageability, furthermore, no interaction with reading group was found. The authors argued that imageability may be mediated by age of acquisition, that is, once age of acquisition is controlled for, imageability effects disappear. However, a number of points must be made about this study. The method of grouping readers would appear to be somewhat problematic. Although there are significant differences between the two groups on the reading comprehension test given at the outset, there appeared to be little difference in the readers on the lexical decision task and no significant differences were found in latencies or accuracy in the naming task. This suggests that the task was really no more difficult for the poor readers which in itself could be one reason why no differences in performance between high and low-imageability words were found. The grouping of readers is also problematic because it was based on performance in a reading comprehension task. It is possible that poor comprehenders were also included in the sample, these subjects may be influenced by the semantic properties of a word in quite a different way from poor readers with decoding problems. Further, no alternative condition is offered in which age of acquisition is varied and imageability is controlled for and therefore it remains unclear whether age of acquisition explains the differences between high and low-imageability words or whether no difference would be found in these tasks across these reading groups anyway.

Coltheart, Laxon and Keating (1988) attempted to address this issue by looking at the effect of imageability and age of acquisition on the accuracy of groups of nine-year-old good and poor readers. In the first task 47 children were presented with 80 words which differed in their rated age of acquisition, 40 were early acquired words and 40 were late acquired words. The words were matched on length, frequency and imageability. Main effects were found for group and word type, good readers were able to read more words than poor readers and words acquired earlier were read more easily than words acquired later. There was also a significant group x age of acquisition interaction in the item analysis but not in the subject analysis. On the second task the children were shown 80 words differing in their imageability, 40 words were of high-imageability and 40 were of low-imageability. A significant effect of reader group and a significant imageability effect was found, high-imageability words being easier to read than low-imageability words. However, a significant interaction, and planned comparisons, indicated that the imageability effect was found only for the poor reader group. It is important to note, however, that these results were not found in the item analysis where no main effect of imageability was found, which limits the conclusions that can be drawn on the basis of these data. It does seem, however, that the poor readers in this study were more affected by imageability than the average readers. Coltheart et al. argue that this might suggest that "less able young readers may rely to some extent on the rather inaccurate, semantically based, predicational route in reading" (p.9). Age of acquisition effects remain important, for both poor and average readers, even when imageability is controlled for and it is important to consider why this might be. The possible effects of age of acquisition will be considered in Section 1.10.3.

In summary, it would seem that the results of these studies suggest a number of things. Firstly, it does seem possible that poor decoders are more likely to rely on semantic coding when that is a possibility. Secondly, although there appears to be some evidence that poor decoders may show greater concreteness effects than average or good readers, suggesting a larger influence of semantic factors in subjects with an impaired phonological pathway, the evidence is far from conclusive.

#### 1.9.1.2. Imageability effects in children with semantic impairments

An alternative way of considering the division of labour hypothesis is to examine the performance of children with poor semantic representations and to consider whether they are more reliant on the phonological pathway than children with better semantic processing skills. Nation and Snowling (1998) predicted that children with poor semantic representations, poor comprehenders, would not only have greater problems with reading and understanding text, but also that they would have greater difficulties in reading exception words. Twenty-seven poor comprehenders were compared with twenty-seven control subjects who were matched on measures of decoding but differed in their listening comprehension skill. The children were required to read 64 words varying in imageability and regularity, these words were the same as those used by Strain et al. and formed 4 groups; high-imageability exception words, high-imageability regular words, low-imageability exception words and low-imageability regular words. The results showed that high-imageability words were read more easily than low-imageability words and regular words were easier to read than irregular words, these two factors, imageability and regularity interacted with each other. A main effect of group and a significant group x imageability interaction was also found, this interaction indicated that the poor comprehenders made more errors on the low-imageability items than the normal readers. The interaction between group and regularity was almost significant, suggesting that poor comprehenders made more errors to exception words than the normal readers. In summary, the results of these studies suggest that children with poorly specified semantic representations have increased problems with exception word reading because their orthographic to phonological translation for these words is not helped by activation in the semantic pathway. Further, although all children had greater difficulties with low-imageability items, this difficulty was particularly pronounced in the poor comprehenders. These results support those found by Strain et al. (1996) by suggesting that when orthographic to phonological translation is difficult word recognition and lexical processing will be more affected by the semantic pathway. These results also suggest that when these semantic representations themselves are poorly specified, as in poor comprehenders, processing of these words will be impaired to a greater extent than for the normal readers, despite the fact that their phonological decoding skills do not differ.

## 1.10. Why should abstract words be more difficult to read ?

It is important to consider what it is about concrete words that makes them easier than abstract words and in doing so to consider how the semantic representations of concrete and abstract words might differ. A number of explanations have been proposed. As suggested above, it is possible that imageability and concreteness effects may actually be accounted for by other variables such as age of acquisition or 'context availability'. Highly imageable or concrete words may be easier to learn because they are the words that are also acquired earliest (Coltheart et al. 1988). Another explanation is that the difference between concrete and abstract words is the amount of contextual information they bring. Some attempt to explain concreteness effects has been made in terms of these differences in contextual availability (Schwanenflugel, Akin & Luh, 1992). It has also been suggested that differences occur because of differences in the way in which sensory information is represented in memory (Paivio 1971; 1986) and possibly even that their meanings are represented in a neuroanatomically distinct way (Breedin et al. 1994). Finally, it is also possible that concrete words are 'richer' in terms of the number of semantic features that define them and it is this which accounts for their processing advantage (Plaut & Shallice 1993).

### 1.10.1. Dual-Coding Theory

One possible explanation of the processing advantage for concrete words is dual-coding theory (Paivio 1986). This theory proposes the existence of two partly interconnected, but functionally independent and distinct representational systems in memory: a verbal system and an image system. The advantage for concrete words is said to arise as a result of stronger connections to the image system. In reading the verbal system must be activated but the image system might also be activated. However, this secondary activation is likely to occur only for concrete words which are also represented in the image system. Concrete words are said to be represented verbally with the possibility of further imaginal activation, whereas abstract words are represented only by the verbal system; performance with concrete words is facilitated because they have, in effect, two representations.

The image system is said to be based on relationships which arise from sensory experience and its development is explained very much in Piagetian terms. According to Piaget, knowledge structures are formed from an interaction between the infant and his or her environment, with sensory-motor schemata developing over time to accommodate new information. Over time this sensory information becomes internalised by the infant as knowledge structures. Paivio suggests that language develops from an initial imaginal base, imagery and language remain interconnected. However, it is proposed that language also develops a partly independent structure and that verbal behaviour is "free of dependence not only upon a concrete situational context but to some extent from imagery as well" (Paivio, 1971, p.438; cf. Bleasdale, 1983).

An extension of this theory is the proposal that concrete and abstract words are represented in neuroanatomically distinct ways. Day (1977) argued that concreteness effects would be modulated by the visual field (and hence hemisphere) of encoding. In a series of lexical decision tasks he found a significant interaction between concreteness and visual field, such that a concreteness effect was found only when the words were presented to the left visual field suggesting a specialised right hemisphere impact. This proposal fits well with the evidence from studies showing that deep dyslexic patients have impaired naming ability for abstract as compared to concrete words. Deep dyslexics are thought to have left hemisphere damage and so the strong concreteness effects that they show have been accounted for in terms of the correct processing of an intact right hemisphere favouring concrete over abstract words (Saffran, Bogoyo, Schwartz & Marin 1980). There is also evidence from patients with semantic memory impairments suggesting that they show a significant advantage for abstract as opposed to imageable words (Breedin, Saffran & Coslett, 1994).

Bleasdale (1987) presents evidence to support the dual-coding hypothesis from a series of priming experiments involving word naming and lexical decision tasks. Associated, unrelated and neutral (BLANK-word) word pairs were used which varied prime and target concreteness. It was found that in the naming tasks associated primes were named faster than neutral targets when primes and targets were homogenous for concreteness (i.e. concrete-concrete or abstract-abstract) but not when the prime and target differed in concreteness. In the lexical decision task priming from all pairs was shown regardless of prime and target concreteness. Bleasdale argued that in the lexical decision task post-lexical rather than lexical processes were being used, that is, the heterogeneous (e.g. concrete-abstract or abstract-concrete) associations in the lexical decision task would be attributable to target-to-prime checking procedures. Conversely, concreteness dependent priming was found in naming tasks which are dependent on lexical processes, therefore suggesting that lexical processes may be functionally distinct for concrete and abstract words.

### 1.10.2. The Context Availability Hypothesis

Schwanenflugel (1991) argues that concreteness effects can be accounted for by the relative ease with which people report being able to retrieve associated information for such words. In obtaining context availability ratings people are asked to rate the ease with which they can think of a sentence for each given word. According to this hypothesis, sensory information does not have a special status but is considered as another example of prior information. He argues that it is the relative ease with which this knowledge is accessed rather than the type of knowledge which is important. Extensional and relational knowledge is important as well as sensory knowledge. As already discussed in Section 1.8.2., McFalls et al. (1996) found significant context availability effects in word learning over and above any effects of concreteness. It has also been shown that adults do not show a concreteness effect when a supportive context is provided. Schwanenflugel & Shobin (1983) found that naming and lexical decision times were faster when abstract words and sentences were preceded by paragraph and sentence contexts as compared with no-context conditions. However, context did not significantly facilitate concrete sentences and words. The authors suggest that the lack a of contextual facilitation effect for the concrete words is due to the fact that the words already have an adequate cognitive context and thus are not aided by additional information. These findings are difficult to explain in terms of the dual-coding hypothesis. If concrete words have easier access to the image system when the words are read in isolation, and this access is based on the sensory information activated by the word then it is hard to explain why this should not be the case also when they are read in context. There is no clear explanation of why abstract words take longer to read in isolation.

Bleasdale (1987) argues that his results provide evidence which questions the role of context availability, further he suggests that context availability cannot adequately explain the priming results obtained. In the experiments described above the Target Concreteness by Prime Context interaction failed to reach significance. If context availability is the crucial factor then a greater facilitation for abstract words would be expected and this was not the case. However, it is important to note that firstly the priming in this experiment was single word priming whereas in the Schwanenflugel study the context was sentences and paragraphs. Secondly, Bleasdale did not obtain context availability ratings so it remains unclear whether the concreteness effects he found were above and beyond and context availability effects.

### 1.10.3. The Role of Age of Acquisition

A further possible explanation for concreteness effects is the age of acquisition hypothesis. There is some evidence for the role of age of acquisition in influencing reading over and above any influence of imageability (Coltheart et al. 1988; Klose et al. 1983). It is clear that imageability is closely related to age of acquisition in some sense. Firstly, there is good evidence to suggest that concrete words are learnt earlier than abstract words (Brown, 1957; Gentner, 1982). Secondly, there is evidence to suggest that imageability correlates very highly with rated age of acquisition. Morrison, Chappell & Ellis (1997) show that imageability correlated with both adult ratings of age of acquisition and child picture naming (indicating actual age of acquisition) more highly than other variables such as frequency.

Given that these two variables are so closely related it is important to consider whether imageability effects may be wholly accounted for by age of acquisition or whether imageability is in itself important, over and above any influence of age of acquisition. In order to answer this question consideration of the mechanisms by which age of acquisition and imageability may influence language processing is necessary. One possible way in which age of acquisition may have an influence on performance in some language tasks is that there is a processing advantage of concrete over abstract words; because concrete words are acquired earlier they have been experienced more often and therefore have lower thresholds of activation. However, it is also the case that concrete words will have been 'experienced' more often than abstract words and therefore this hypothesis does not exclude the possibility that it is imageability rather than age of acquisition per se which is important.

Age of acquisition effects may also be considered within a dual-coding approach. Paivio supports a Piagetian view of language development, proposing that language is initially tied to sensory interaction with the environment. This would suggest a reason why concrete words are acquired earlier than abstract words. By their very nature concrete words tend to be more tied to the sensory environment. As Gentner (1982) suggests:

"Children learn concrete nouns early because, as object-reference terms, they have particularly transparent semantic mapping to the perceptual-conceptual world . . . Words that refer to these concepts are easy to learn because the child has already formed object concepts and need only match word concepts." (pp 53-54).

Dual-coding theories might suggest then that age of acquisition is important because sensory information 'leads' language development (forming an imagen system). Nevertheless, a central tenet of dual-coding theories is that as well as this imagen system a separate system also exists for dealing with verbal information. Therefore, dual-coding theorists would reject claims that more experience is what gives age of acquisition its importance, age of acquisition is only important to the extent to which concrete words are acquired earlier than abstract words. Concreteness, in allowing access to both verbal and imagen systems, is a variable which is important in itself, even after age of acquisition is taken into account. In terms of the context availability hypothesis, Schwanenflugel (1991) points out that the age of acquisition hypothesis has some difficulty in explaining why the differences seen between the processing of concrete and abstract words disappears when the words are presented in context.

### 1.10.4. Featural Representations of Semantics

One further way of considering concreteness effects is within a connectionist framework. Just as the Seidenberg and McClelland (1989) model, discussed in Section 1.6.4., represents phonology in terms of featurally distributed representations, it might also be possible to argue that semantics can also be represented in a similar way (Plaut & Shallice, 1993). McRae, de Sa & Seidenberg (1997) suggest that word meanings are represented in terms of correlated features. Words are composed of semantic features. A model might not only learn that a tiger 'has fur' but also that 'has fur' is a feature of many animals and that animals (that have fur) also tend to 'have claws' and 'have a tail'. The number of features and the number of correlations between features predicts the speed and accuracy of recognition. According to this approach concrete words are processed more easily than abstract words because they activate a greater number of features. It is possible that both the age of acquisition hypothesis and the context availability hypothesis could be subsumed into this approach. Earlier acquired words may receive more activation than later acquired words because they have a greater number of features and correlated features. It is possible that it is this which in part determines the ease, and therefore, age of acquisition. Similarly words in context may receive greater facilitation than those in isolation.

### 1.10.5. Summary

In summary, it would seem that the reason why imageability or concreteness should have an effect on language processing remains unclear. Although a number of theories have been suggested none of these is without its problems and it would seem that the effect of concreteness is a complex one. Even though the exact nature of the influence of concreteness is unclear the results are clear in suggesting an influence of some type of semantic variable on isolated word recognition. Whether this is conceived of as an influence of context availability, or within a dual-coding framework or as a product of differences in featurally based semantic representations, the evidence shows that this semantic variable can influence single word recognition.

## 1.11. Conclusions

This chapter has reviewed a substantial body of literature concerned with both phonological and semantic factors influencing reading development. The evidence reviewed suggests that phonological skills, both in terms of metacognitive awareness of phonology, and in the way in which phonology is represented by children, have a strong influence on reading development. There is also evidence that semantic factors have a role to play, although the role of semantics in the earliest stages of reading development and the way in which semantic and phonological factors interact throughout reading development appear to be little understood.

Traditional stage models have argued that children in the very earliest stages of reading development are influenced by the visual features of a word they are learning to read but are not influenced by the phonological features of the word. However, as discussed in this chapter, there is good evidence to suggest that children are able to use phonology at a very early stage. There is evidence that children are able to use phonology before they are consciously aware of it, or able to reflect upon it. This early use of phonology and how it relates to children's phonological awareness skills will be examined in this thesis. Similarly, most models of reading development stress the primacy of phonological skills in learning to read and suggest that semantic factors do not influence reading until a later stage of development. However, there is some evidence to suggest that children are sensitive to semantic factors from an early stage. In this thesis, the extent to which learning to read a word is influenced by semantic factors, as well as phonological factors in very early reading development will be investigated. The relationship between phonological and semantic factors, and the ways in which they may interact to influence reading development, will also be considered.

# Chapter Two

# The Relationship between Phonological Awareness and the Implicit use of Phonology in Beginning Reading

## 2.1 Overview

An experiment examining children's early use of phonology in learning to read is presented in this chapter. Children's ability to access and use phonology is examined using the paradigm used by Ehri & Wilce (1985) and Rack et al. (1994), as discussed in Chapter 1. The ability of children to learn to associate three letter abbreviated cues with spoken words is related to their performance in phonological awareness tasks. The results are discussed in the light of previous research and models of reading development.

## 2.2 Introduction

As discussed in Chapter 1, many models of reading development have proposed that young children initially learn to read words on the basis of salient visual features (Marsh et al. 1981, Frith 1985). However, evidence was also discussed which suggested that this early 'visual' stage is of short duration and that phonological processes influence the development of word recognition skills from an early stage, before children can be said to have entered a full 'alphabetic phase' (Stuart & Coltheart, 1988; Ehri & Wilce, 1985). Ehri (1992) argued that children in the early stages of reading are sensitive to the phonetic information in words and use this information in forming connections between the printed word and its pronunciation. She argued that children set up partial associations between some of the letters in the word and the phonemes for which they stand. These partial associations are not the same as decoding in a conscious letter by letter manner.

In a similar vein Rack et al. (1994) proposed a 'direct mapping mechanism', according to which children are able to set up direct, although far from systematic, mappings between orthography and phonology. Rack et al. demonstrated that children in the very early stages of learning to read are sensitive to phonological information in words and are able to use this information in learning to read them. Furthermore, they are able to access much smaller units of phonology than they are consciously aware of, in terms of performance in phonological awareness tasks.

This chapter further examines children's sensitivity to phonology in the early stages of reading development and considers how this sensitivity might change with development. A further issue is how the ability to access phonology in learning to read relates to performance in phonological awareness tasks.

## 2.3 Experiment 1

### 2.3.1 Introduction

This experiment is based on the study by Rack et al. discussed in Chapter 1. Rack et al. taught children to associate three letter abbreviated words with spoken words. Two types of cue were created; phonetic cues, in which the central phoneme in the cue was phonetically similar to one in the target word and control cues in which the central phoneme was phonetically dissimilar (or less similar) to one in the target word. For example, for the target word BEAVER the phonetic cue was BFR and the control cue was BZR. In the phonetic cue condition the medial phoneme differed form that in the target word only in voicing, whereas in the control condition the phoneme differed in terms of place of articulation. Rack et al. found that young children at a very early stage of reading development, who were unable to decode even the simplest CVC words, were able to learn to associate the phonetic cues with the correct pronunciation more easily than the control cues.

This experiment used the same cues as those used in the Rack et al. study. An important aim of this experiment was to examine the relationship between learning these cues and performance in phonological awareness tasks. It is argued that the process of learning to read these three letter cues is analogous to the process of learning to read words in the early stages of reading development. Children are able to extract partial phonological information from the cue or word and map this onto the printed form. Performance in this task may also be seen as a measure of the rate learning in reading. It is predicted that the rate of learning in this task will be related to individual differences in phonological awareness.

A further aim of this study was to look at the way in which children's ability to learn to associate an abbreviated word cue with a spoken word might change with development. Rack et al. argued that this cue learning task taps the processes used to set up connections between the cue and the underlying phonological representation of the word. If the characteristics and organisation of these phonological representations change with development these changes might well be reflected in the child's learning in the phonetic cue paradigm. As discussed in Chapter 1, there is evidence to suggest that young children's lexical representations for speech may initially be relatively holistic and become increasingly segmental (phonemic) with development (Walley 1993). A tentative prediction from this is that young children may show a greater advantage in learning the phonetic cues than older children. It may be that the less well differentiated phonological representations of the beginning reader would in some sense allow them to confuse the phoneme that is globally similar to produce the phonetic cue effect. However, the more clearly specified, segmentally organised representations of older children might tend to reduce their sensitivity to the featural similarity of phonemes.

## 2.3.2 Method

### 2.3.2.1 Participants

Sixty children, 30 boys and 30 girls from a Primary School in York took part in the experiment. The majority of the children came from middle class backgrounds. The children were equally spread over three year groups at school, 20 children from the reception class, with mean age of 4 years 8 months (range 4 years 7 months to 5 years 2 months); 20 children from year one, with a mean age of 5 years 8 months (range 5 years 3 months to 6 years 10 months); and 20 children from year two, with a mean age of 6 years 10 months (range 6 years 5 months to 7 years 4 months).

Reading is taught in the school using a variety of methods combining phonic and whole language approaches, using a reading scheme, language games and 'real books'.

### 2.3.2.2 Design and Materials

All the children were given a battery of phonological awareness tasks from the Phonological Abilities Test (Muter, Hulme, & Snowling 1997), measures of reading ability and the experimental word learning task. Each of these tasks is described briefly below.

**(i) Rhyme Detection** This test comprises three demonstration items and ten test items. All the items are accompanied by pictures. The child is required to indicate which of three words rhymes with a stimulus word. The child scores either 1 for a correct response or 0 for an incorrect response. The total possible score is 10.

**(ii) Rhyme Production** In this task the child is given 30 seconds to supply words or nonwords that rhyme with each of the two stimulus words, 'day' and 'bell'. The child's responses were recorded. The child's score for the rhyme production test is the total number of correct rhyming responses for both words.

**(iii) Phoneme Deletion** In this task the child is required to remove the initial phoneme from a single syllable word. The correct response is also a word. For example, *meat* without the /m/ is *...eat*. There are four demonstration items, followed by 8 test items, all accompanied by pictures. The child's response is recorded and scored, 1 (correct) and 0 (incorrect). This test is then repeated with another set of single syllable words and the child is asked to delete the final phoneme. The total possible score for the phoneme deletion task is 16.

**(iv) Syllable and Phoneme Segmentation** In this task the examiner supplies the first part of the word which the child is then required to finish off, for example, 'here is a ra...(rabbit)' and the child is required to say /bit/. There are 16 items which are presented with pictures. The first 8 items require the child to supply the second syllable of a two-syllable word. The second 8 items require the child to supply the final phoneme of a single syllable word. There are four demonstration items. The items are scored 1 or 0 and the total possible score is 16.

**(v) Speech Rate** This test involves the child repeating a word over and over again as fast as they can. The examiner times how long it takes the child to produce 10 repetitions. There is a practice item when the child repeats his or her name. The child is then asked to repeat the word 'buttercup' as fast as they can. Their performance with the word buttercup is measured three times: the average time is then converted into a speech rate in words per second.

**(vi) Letter Knowledge** Letter-sound knowledge was assessed by asking the children to give the name or sound of the letters of the alphabet which were presented individually, in a random order, on printed cards.

**(vii) Single Word Reading** Reading ability was assessed using a graded test of single word naming, the British Ability Scales test of Word Reading (Elliot, Murray, & Pearson 1983). Testing was discontinued if the child made 10 consecutive errors.

**(viii) Nonword Reading** To assess the children's ability to use letter-sound rules for decoding novel words the Graded Nonword Reading Test (Snowling, Stothard & McLean, 1996) was used. The test comprises a set of 20 nonwords which are graded in difficulty: there are 10 1-syllable and 10 are 2-syllable items. An additional four simple 1-syllable items were included in an attempt to make sure that the test would be sensitive to variations in skill amongst the youngest children tested (4 year olds). The child scores 1 for a correct response and 0 for an incorrect response, giving a maximum possible score of 24.

**(ix) Definitions** The children were asked to provide definitions for each of the words they were to learn to read in the word learning task. These definitions were then given a score of 0, 1 or 2 depending on the depth of understanding of the word shown, giving a maximum possible score of 48.

**(x) The Word Learning Task** The experimental word learning task required the child to learn the pronunciations associated with three or four letter abbreviations (cues). Twenty four target-cue pairings were taught in three blocks of eight items spread over 3 days of testing. The target words were the same as those used by Rack et al. (1994). The target words were all bisyllabic words with a CVCVC or CVCV phonemic structure. Twenty of the cues were three letters in length and the remaining four were four letters in length. The cues contained two letters (three for the four-letter cues) whose corresponding phonemes occurred in the target word and a single medial letter whose corresponding phoneme did not occur in the target word. In the phonetic cue condition the middle phoneme was similar to a phoneme in the target word in terms of place and manner of articulation but different in voicing. Five voice/voiceless pairs were used to form the phonetic cues : t/d, p/b, s/z, f/v, and k/g. In the control condition the central phoneme in the cue always differed from that in the target word in place of articulation (and sometimes also in voicing). So, for example for the target word TABLE the phonetic cue was TPL and the control cue would be TGL the 'b' and the 'p' differing only in terms of voicing, while the 'b' and the 'g' differ in voicing and place. A full list of all the stimuli is given in the table below.

**Table 2.1**

Target words and cues used in Experiment One

| Target Word | Phonetic | Control | Target Word | Phonetic | Control |
|---|---|---|---|---|---|
| *beaver* | bfr | bzr | *packet* | pgt | ppt |
| *biscuit* | bzkt | bfkt | *pattern* | pdn | pkn |
| *bucket* | bgt | bpt | *puddle* | ptl | pgl |
| *button* | bdn | bpn | *puzzle* | psl | pvl |
| *cabin* | kpn | kgn | *secret* | sgt | spt |
| *coffee* | kvi | ksi | *silver* | slfr | slzr |
| *cotton* | kdn | kgn | *soccer* | sgr | str |
| *cover* | kfr | kzr | *supper* | sbr | skr |
| *foggy* | fki | fbi | *table* | tpl | tgl |
| *garden* | gtn | gbn | *table* | tpl | tgl |
| *gravy* | grfi | grzi | *target* | tkt | tbt |
| *gutter* | gdr | gkr | *ticket* | tgt | tpt |
| *packet* | pgt | ppt | *travel* | trfl | trzl |

Two forms of the experiment were constructed so that each target word appeared in each form once, in either the phonetic or control condition. Each form of the experiment contained 24 words, 12 phonetic cue words and 12 control cue words. The cues were then grouped in three blocks of eight with four phonetic cues and four control cues in each block of eight. Each child was presented with one block a day for three consecutive days. The order of presentation of each of the three word groups was counterbalanced.

#### 2.3.2.3 Procedure

The Phonological Abilities Test and reading tests (BAS word reading and the Nonword reading test) were administered first. In the case of the reception children this was done over two days but the Year 1 and Year 2 children completed these tests in one day. The testing took place in an area adjacent to the classroom.

For the word learning task the children were tested individually in a quiet room in their school on three consecutive days. On each day they were taught to associate eight printed cues with their pronunciations. The children were told they were going to learn some 'made up words'. Each cue was presented to the child and the experimenter said the target word twice with the child repeating the word once. On the first presentation the card remained in view for approximately 5 seconds. The cards were then shuffled and presented to the child who was asked to say the spoken word that had been paired with each cue. Refusals and errors were corrected. Testing was discontinued after six test runs. The child scored 1 for a correct response and 0 for an incorrect response giving a total possible score of 6 for each cue word. With 12 words in each condition the maximum possible score for each condition was 72.

## 2.4 Results

### 2.4.1 Word Learning Task

The results of the word learning task are shown in Table 2.2. It is clear that older children learn better than younger children, that the phonetic cues were learnt more easily than the control cues and that the size of this phonetic cue advantage does not differ as a function of age.

**Table 2.2**

The mean cue learning scores (and std. deviations) for each age group

| | Phonetic Cues | Control Cues |
|---|---|---|
| **Reception** | 21.65 (13.39) | 17.30 (13.05) |
| **Year 1** | 40.80 (15.60) | 34.45 (13.06) |
| **Year 2** | 49.45 (10.90) | 41.35 (16.22) |

The data were subjected to a within-subjects analysis of variance in which the factors were Cue Type (phonetic or control) and Group. There was a strong main effect of Group ($F(2,57)=20.17$, $p < .0001$) and a strong main effect of Cue Type ($F(1,57)=38.02$, $p < .001$). This confirms the hypothesis that children learn to associate phonetic cues with a target word more easily than control cues. There was no significant Group x Cue Type interaction (by subjects ($F(2,57)=1.13$, $p > .1$). There is therefore no support for the hypothesis that the phonetic cue advantage might decline with age.

The data were analysed across items as well as across subjects. The item means in each condition are given in Table 2.3. A strong main effect of group (($F(2,48)=118.81$, $p<.001$) and a strong main effect of cue type ($F(1,24)=16.47$, p<.001)was found across items. The Group x Cue Type interaction was not significant ($F(2,48)=1.26$, $p>.05$). The item analysis, therefore confirmed the findings of the subject analysis.

**Table 2.3**

Item means for each condition

| | Phonetic Cues | Control Cues |
|---|---|---|
| **Reception** | 1.9 (.86) | 1.5 (.78) |
| **Year 1** | 3.4 (.89) | 2.8 (.97) |
| **Year 2** | 4.1 (.72) | 3.4 (.95) |

It is believed that children are using phonological processes in learning to recognise printed words before they are able to use letter-sound decoding skills. However, it is clearly the case that some children in this study do possess such decoding skills and it was thought necessary, therefore, to create a sub-group of children who could read one or less nonword in order to assess the extent to which the phonetic cue effect occurs in children who have not developed effective decoding skills. Across the three age groups there were 23 children who satisfied this criterion. Sixteen of these children were from the Reception Class and seven were from Year One. The mean phonetic cue score for this group of non-decoders was 21.65 (SD 12.42) and their mean control cue score was 17.39 (SD 12.68): this difference is significant ($F(1,22) = 7.53$, $p < .05$), confirming that even children without letter-sound decoding skills find it easier to learn cues that are phonetically similar to target words than control cues. This shows, in line with earlier findings (Rack et al., 1994) that the phonetic cue effect exists in children who possess no appreciable phonic decoding skills.

### 2.4.2 The Phonological Awareness Tests

The scores on each of the phonological awareness tasks and the definitions task, for each age group, are presented in Table 2.4. It can be seen from the table that there is a steady increase in performance on each of these tasks as a function of age.

**Table 2.4**

Mean performance (and standard deviations) of the three groups of children on the language and reading tasks

| Task | Reception | Year 1 | Year 2 |
|---|---|---|---|
| Letter Knowledge | 15.6 (8.62) | 23.85 (1.84) | 24.6 (1.19) |
| BAS Reading | 3.1 (6.92) | 14.55 (14.90) | 37.6 (24.86) |
| Nonword reading | .90 (2.02) | 5.3 (5.11) | 13.2 (8.18) |
| Rhyme detection | 5.15 (3.12) | 7 (2.77) | 8.5 (2.06) |
| Rhyme production | .85 (1.69) | 3.25 (3.35) | 8.35 (4.51) |
| Phoneme deletion | 1.25 (2.12) | 7.2 (6.03) | 11.65 (3.59) |
| Syll. and Phoneme Segmentation | 6.5 (5.71) | 9.7 (5.01) | 13.2 (3.56) |
| Speech rate(wd/sec) | 1.22 (.43) | 1.22 (.5) | .91 (.22) |
| Definitions | 31.79 (6.55) | 34.5 (4.97) | 40.80 (4.4) |

In order to examine the relationship between performance in the word learning task and measures of phonological awareness correlations were computed; these are shown in Table 2.5. The top half of the table shows partial correlations with age controlled for, the bottom half of the table shows the raw correlations between measures across all groups. It is apparent, as would be expected, that the phonological awareness measures all correlated strongly with each other (cf. Wagner & Torgeson 1987; Lundberg, Olofsson & Wall, 1980).

**Table 2.5**

Correlations between measures of phonological skill, single word reading and word knowledge (definitions)

| | Rhyme Detect. | Rhyme Product. | Segmentation | Phoneme Deletion | Speech Rate | Letter Knowl | BAS Reading | Definition |
|---|---|---|---|---|---|---|---|---|
| Rhyme Detect. | | .21 | .53** | .37* | -.13 | .43** | .15 | .29* |
| Rhyme Prod. | .49** | | .23 | .19 | -.11 | .06 | .33* | .07 |
| Segmentation | .60** | .49** | | .42** | -.29* | .49** | .37* | .49** |
| PhonemeDel. | .56** | .61** | .63** | | -.01 | .18 | .52** | .32* |
| Speech Rate | - .27* | - .35* | - .46** | - .31* | | -.07 | .11 | -.14 |
| Letter Knowl | .55** | .44** | .65** | .55** | - .31* | | .03 | .18 |
| BAS Reading | .45** | .66** | .57** | .76** | - .37* | .44** | | .27* |
| Definition | .48** | .41** | .63** | .58** | -.33* | .44** | .54** | |

***= P<.001; *= P<.05*

### 2.4.3 Relationships between cue-word learning phonological awareness and knowledge of word meanings

Next the relationship between the phonological measures, the word definitions task and performance in the word learning task was examined. It was thought to be of interest to investigate whether the extent to which children showed the phonetic cue effect (that is, learnt the phonetic cues more easily than the control cues) was related to their performance in the word learning task. One way of examining the phonetic cue effect would be to take a simple difference score, for example,:

effect = phonetic cue score - control cue score

However, there are a number of problems with the use of such difference scores. Such a difference score would be less reliable than either of the separate phonetic and control cue scores. In addition these separate scores are themselves correlated which means that such an effect score will not produce a measure of the extent to which children learn the phonetic cues more easily than the control cues independently of the control cue score. A solution to these problems that has been recommended is to examine the difference between phonetic and control cue scores by partialling out the effects of one on the other so that they are uncorrelated (Cohen & Cohen 1983).

Prediction of the phonetic cues was therefore examined after the control cue learning score had been partialled out.

In order to examine the relationship between the phonological awareness measures and performance in the word learning task two measures from the word learning task were used. The phonetic cue score was correlated with the measures of phonological awareness while controlling for the control cue score, as described above. The total score is the sum of the phonetic and control cue scores and gives a measure of overall learning in the task.

The correlations between the phonological awareness measures, the word definitions task, and performance in the cue learning task are shown in Table 2.6. It is apparent that the phonological measures and the word definitions task are strongly correlated with children's overall performance on the word learning task. It would seem that children's success in learning the cues is predicted both by phonological and semantic factors. Furthermore, the phonetic cue score was found to correlate significantly with measures of rhyme detection, syllable and phoneme segmentation, phoneme deletion and letter knowledge. This suggests that children's sensitivity to the phonetic quality of the cue is related to their performance in the phonological awareness tasks.

**Table 2.6**

Correlations between measures of phonological skill, single word reading and performance in the word learning task

| | Rhyme Detect. | Rhyme Product. | Segmentation | Phoneme Deletion | Speech Rate | Letter Knowl. | BAS Reading | Nonword Reading | Definitions. |
|---|---|---|---|---|---|---|---|---|---|
| Phoncue | .40* | .14 | .40* | .55* | .06 | .29* | .14 | .22 | .22 |
| Total | .61** | .58** | .67** | .80** | -.36** | .59** | .74** | .77** | .67** |

***= p<.001; *= p<.05*

To explore the extent to which measures of phonological awareness and word knowledge (definitions) could account for variance in performance in the cue learning task a series of regression analyses was conducted. In the first analyses the total cue learning score was taken as the dependent variable. In a hierarchical regression, age and the BAS single word reading score were entered first and accounted for a large amount of the variance in the total score (59.7%, $p$ <.001)). After these factors had been controlled for, the phonological awareness measures and the definition score were entered into the equation. A series of hierarchical regression analyses were conducted in which each of these predictor variables was entered on the last step. The variance accounted for by each variable when entered on the last step is shown in Table 2.6. These analyses showed that two variables accounted for unique variance in the total cue learning score after all the other variables had been entered: these were phoneme deletion (2.7%, $p > .05$) and the word definitions score (2.6%, $p < .05$).

**Table 2.7**

Summary of hierarchical regression with total score as the dependent variable

| STEP | VARIABLE | % VARIANCE |
|---|---|---|
| 1. | Age & BAS | 59.7** |
| 2. | Speech rate | 0.1 |
| 3. | Letter | 4.5* |
| 4. | Rhyme Production | 0 |
| 5. | Rhyme Detection | 4.4* |
| 6. | Identification | 1.0 |
| 7. | Phoneme Deletion | 3.28 |
| 8. | Definitions | 2.6* |
| 2. | Letter | 4.6* |
| 3. | Rhyme Production | 0 |
| 4. | Rhyme Detection | 4.5* |
| 5. | Identification | 1.0 |
| 6. | Phoneme Deletion | 3.3* |
| 7. | Definitions | 2.3 |
| 8. | Speech Rate | 0 |
| 2. | Rhyme Production | 0.1 |
| 3. | Rhyme detection | 8.0** |
| 4. | Identification | 1.7 |
| 5. | Phoneme Deletion | 3.3* |
| 6. | Definitions | 2.4* |
| 7. | Speech Rate | 0 |
| 8. | Letter | 0.5 |
| 2. | Rhyme Detection | 8.1** |
| 3. | Identification | 1.7 |
| 4. | Phoneme Deletion | 3.3* |
| 5. | Definitions | 2.5* |
| 6. | Speech Rate | 0 |
| 7. | Letter | 0.5 |
| 8. | Rhyme Production | 0 |
| 2. | Identification | 6.6* |
| 3. | Phoneme Deletion | 4.8* |
| 4. | Definitions | 2.6* |
| 5. | Speech Rate | 0 |
| 6. | Letter | 0.9 |
| 7. | Rhyme Production | 0 |
| 8. | Rhyme Detection | 1.1 |
| 2. | Phoneme Deletion | 8.0** |
| 3. | Definitions | 4.9* |
| 4. | Speech Rate | 0.1 |
| 5. | Letter | 1.7 |
| 6. | Rhyme Production | 0 |
| 7. | Rhyme Detection | 1.2 |
| 8. | Identification | 0 |
| 2. | Definitions | 7.6** |
| 3. | Speech Rate | 0 |
| 4. | Letter | 2.9* |
| 5. | Rhyme Production | 0.1 |
| 6. | Rhyme Detection | 2.6* |
| 7. | Identification | 0 |
| 8. | Phoneme Deletion | 2.7* |

Further regression analyses were carried out to examine the extent to which the phonological variables and word definitions task could explain variance in the extent to which children learnt the phonetic cues more easily than the control cues. It is possible to predict that children with good phonological skills will show a greater sensitivity to the phonetic information in the cues than those with poor phonological skills. Once again a series of hierarchical regressions were conducted. The dependent variable in these analyses was the phonetic cue learning score. By entering the control cue learning score on the first step, along with age and the BAS reading score, it is possible to examine the extent to which performance in the phonological awareness tasks predicts children's sensitivity to the phonetic information in the cue, that is, the extent to which they learn the phonetic cues more easily than the control cues. When each of the other predictor variables was entered as the last step phoneme deletion was the only variable to account for unique variance after all the other variables had been controlled for (2.2%, $p < .05$). The variance accounted for by each variable is shown in Table 2.8.

**Table 2.8**

Summary of hierarchical regression with phonetic cue score as the dependent variable

| STEP | VARIABLE | % VARIANCE |
|---|---|---|
| 1. | Age & BAS & Control Cue | 83.4** |
| 2. | Definitions | .04 |
| 3. | Letter | 0.4 |
| 4. | Rhyme Detection | 1.2* |
| 5. | Rhyme Production | 0 |
| 6. | Segmentation | 0.7 |
| 7. | Speech Rate | 0.8 |
| 8. | Phoneme Deletion | 2.2* |
| 2. | Letter | 0.5 |
| 3. | Rhyme Detection | 1.3* |
| 4. | Rhyme Production | 0.1 |
| 5. | Segmentation | 0.9 |
| 6. | Speech Rate | 0.8 |
| 7. | Phoneme Deletion | 2.2* |
| 8. | Definitions | 0 |
| 2. | Rhyme Detection | 1.8* |
| 3. | Rhyme Production | 0.1 |
| 4. | Segmentation | 0.9 |
| 5. | Speech Rate | 0.9 |
| 6. | Phoneme Deletion | 2.2* |
| 7. | Definitions | 0 |
| 8. | Letter | 0 |
| 2. | Rhyme Production | 0 |
| 3. | Segmentation | 2.3* |
| 4. | Speech Rate | 0.9 |
| 5. | Phoneme Deletion | 2.6** |
| 6. | Definitions | 0 |
| 7. | Letter | 0 |
| 8. | Rhyme Detection | 0.2 |
| 2. | Segmentation | 2.1* |
| 3. | Speech Rate | 0.9 |
| 4. | Phoneme Deletion | 2.6** |
| 5. | Definitions | 0 |
| 6. | Letter | 0 |
| 7. | Rhyme Detection | 0.2 |
| 8. | Rhyme Production | 0 |
| 2. | Speech Rate | 0.4 |
| 3. | Phoneme Deletion | 3.9** |
| 4. | Definitions | 0.2 |
| 5. | Letter | 0.2 |
| 6. | Rhyme Detection | 0.5 |
| 7. | Rhyme Production | 0 |
| 8. | Segmentation | 0.7 |
| 2. | Phoneme Deletion | 4.1** |
| 3. | Definitions | 0.2 |
| 4. | Letter | 0.2 |
| 5. | Rhyme Detection | 0.5 |
| 6. | Rhyme Production | 0 |
| 7. | Segmentation | 0.4 |
| 8. | Speech Rate | 0.4 |

### 2.4.4 Predicting Variations in Word Reading Skill from the Experimental Measures

A child's score on the BAS word reading test can be regarded as a measure of their sight vocabulary in reading. It is of interest to ask to what extent the experimental measures can account for variations in this measure. To assess this a further series of hierarchical regression analyses were conducted with BAS word reading scores as the dependent variable. In all these analyses age and the control cue score were always entered on the first step, and together accounted for 64% ($p<.001$) of the variance in single word reading. The amount of variance accounted for by each variable when entered on the final step is shown in Table 2.9.

Given the large amount of variance (64%) in the BAS scores accounted for by age and the control cue score, it is perhaps unsurprising that few variables add further significant variance. Table 2.9 shows that only phoneme deletion accounts for unique significant variance when added on the final step. The phonetic cue score did not account for significant variance in single word reading when the control cue score was controlled for. However, given the small effect size (i.e., the difference between the learning of phonetic and control score) this is not surprising.

## Table 2.9

Summary of hierarchical regression with BAS as the dependent variable

| STEP | VARIABLE | % VARIANCE |
|---|---|---|
| 1. | Age & Control Cue Score 64** | |
| 2. | Definitions | 0 |
| 3. | Letter Knowledge | 0.7 |
| 4. | Rhyme Detection | 0 |
| 5. | Rhyme Production | 2.5 (p<.06) |
| 6. | Segmentation | 2.4 (p<.06) |
| 7. | Speech Rate | 0 |
| 8. | Phoneme Deletion | 3.7* |
| 9. | Phonetic Cue Score | 1 |
| 2. | Letter Knowledge | 0.7 |
| 3. | Rhyme Detection | 0 |
| 4. | Rhyme Production | 2.5 (p<.06) |
| 5. | Segmentation | 2.4 (p<.06) |
| 6. | Speech Rate | 0 |
| 7. | Phoneme Deletion | 3.7* |
| 8. | Phonetic Cue Score | 1.1 |
| 9. | Definitions | 0 |
| 2. | Rhyme Detection | 0.2 |
| 3. | Rhyme Production | 2.6* |
| 4. | Segmentation | 1.6 |
| 5. | Speech Rate | 0 |
| 6. | Phoneme Deletion | 4* |
| 7. | Phonetic Cue Score | 1.1 |
| 8. | Definitions | 0 |
| 9. | Letter Knowledge | 0.8 |
| 2. | Rhyme Production | 2.3* |
| 3. | Segmentation | 0.8 |
| 4. | Speech Rate | 0 |
| 5. | Phoneme Deletion | 3.5* |
| 6. | Phonetic Cue Score | 1.6 |
| 7. | Definitions | 0 |
| 8. | Letter Knowledge | 1.3 |
| 9. | Rhyme Detection | 0.7 |
| 2. | Segmentation | 1.2 |
| 3. | Speech Rate | 0 |
| 4. | Phoneme Deletion | 3.8* |
| 5. | Phonetic Cue Score | 2 |
| 6. | Definitions | 0 |
| 7. | Letter Knowledge | 1.5 |
| 8. | Rhyme Detection | 0 |
| 9. | Rhyme Production | 1.2 |
| 2. | Speech Rate | 0.2 |
| 3. | Phoneme Deletion | 4.7* |
| 4. | Phonetic Cue Score | 1.4 |
| 5. | Definitions | 0 |
| 6. | Letter Knowledge | 0.1 |
| 7. | Rhyme Detection | 0.2 |
| 8. | Rhyme Production | 1.7 |
| 9. | Segmentation | 1.6 |
| 2. | Phoneme Deletion | 4.5* |
| 3. | Phonetic Cue Score | 1.6 |
| 4. | Definitions | 0 |
| 5. | Letter Knowledge | 0.5 |
| 6. | Rhyme Detection | 0.1 |
| 7. | Rhyme Production | 1.8 |
| 8. | Segmentation | 1.7 |
| 9. | Speech Rate | 0 |

| | | |
|---|---|---|
| 2. | Phonetic Cue Score | 0 |
| 3. | Definitions | 0 |
| 4. | Letter Knowledge | 0.7 |
| 5. | Rhyme Detection | 0 |
| 6. | Rhyme Production | 2.5 (p<.06) |
| 7. | Segmentation | 2.4 (p<.06) |
| 8. | Speech Rate | 0 |
| 9. | Phoneme Deletion | 4.7* |

## 2.5 Discussion

The results of this experiment replicate and extend those of the Rack et al. study. The experiment provides further evidence to suggest that children in the very early stages of reading development are sensitive to the relationship between the sounds of letters in printed words and their spoken pronunciation. It has also been shown that both the overall rate of learning these cues and the sensitivity to the phonetic cue effect are related to independent measures of phonological skill. Furthermore, it was shown that this effect did not vary as a function of age. Interestingly, knowledge of the meanings of words was shown to influence the ease with which the cues were learnt.

As discussed in Chapter 1, there is plenty of evidence showing an association between performance on phonological awareness tasks and reading skills. However, the link demonstrated here between phonological awareness and the rate at which beginning readers are able to learn to read novel items has not been shown before. The rate at which these cues are learned may be considered to measure the rate of learning in reading. The results of this experiment suggest that the rate at which children learn to read words is strongly linked to their phonological skills: children with good phonological skills learn to read the cues more quickly than those with poor phonological skills. It was shown that phonemic awareness was a particularly strong predictor of the rate of learning these cues.

Along with the findings of Rack et al., this experiment supports the distinction between conscious awareness of phonological information, as measured by the phonological awareness tasks, and the implicit use of phonology. Although young children may have difficulty with small units of phonology in phonological awareness tasks, it is clear that they can access fine grained phonological representations in the phonetic cue learning task in this experiment. As suggested in Chapter 1, it is possible that it is the quality of the children's phonological representations themselves which are important in reading and that phonological awareness tasks merely tap these representations indirectly (Snowling & Hulme, 1994).

The findings of this experiment can be related to Seidenberg and McClelland's (1989) distributed developmental model of reading. This model learns the mappings between sequences of letters and their pronunciations and these mappings operate automatically and unconsciously in word recognition. As suggested in Chapter 1, the fact that connectionist models such as this one, employ featurally-based distributed representations of phonology provides a way of thinking about the phonetic cue effect. A system that employs such representations of speech sounds would be expected to be sensitive to similarities between sounds as the children in this study were. The model also suggests that, in terms of the development of word recognition processes, a single mechanism may be in operation from the start, that is, no separate decoding mechanism is needed. The fact that even the 'nondecoders' in this study learnt phonetic cues more easily than control cues, provides support for the idea of a single mechanism. It could be argued that learning such direct mappings depends on the quality of underlying representations of phonology which are accessed in the cue learning task. Furthermore, it is the quality of these representations which may in some sense be measured indirectly by the phonological awareness tasks. That learning is dependent on these underlying representations, is suggested by the fact that children are sensitive to much smaller units of phonology than they are consciously aware of.

One aim of this experiment was to look at the way in which children's ability to learn to associate the cues with target words changes with development. A tentative prediction was that as children get older their phonological representations would become more fine grained and better specified and hence that they would no longer confuse globally similar phonemes and as a result the phonetic cue effect would decrease in size. The results of this experiment, however, do not support this hypothesis. Performance on the cue task did not interact with age and, if anything, the phonetic cue effect tended to increase rather than decrease in size with age. The findings do not suggest that the nature of the phonological representations underlying early word learning change in their nature or organisation in the age range (4 to 7 years) studied here.

A further aim was to consider the way in which semantic knowledge of a word might influence the ease with which it is learnt by children in the early stages of reading development. Although the measure of semantic skill used here is a rather crude one, the results nonetheless point to a relationship between a child's knowledge of the meaning of a word and how easily they learn to read it. As discussed in Chapter 1, models of reading development have, for a long time, focused primarily on phonological skills and have rather down played the possible role of semantics in the early stages of reading. However, the results of this study suggest, perhaps 'unsurprisingly, that when children have a weak semantic representation of a word, or do not know its meaning at all, their ability to learn to read the word is severely impaired.

It is possible that the role of semantics in learning to recognise words may be considered as a second form of direct mapping, working in parallel with the processes involved in mapping phonology onto orthography. The Plaut, McClelland, Seidenberg & Patterson (1996) connectionist model of reading, discussed in Chapter 1, incorporated a contribution from semantics and found that in comparison to a model trained without additional support from semantics learning was improved. In terms of the development of reading, Plaut et al. argue that in the early stages of development the phonological pathway is primary, but that as learning progresses semantic contributions to word recognition processes may increase, and that these may be particularly important for learning the pronunciation of low-frequency exception words. Clearly children in the present study must be using the phonological pathway to learn the cues and the very fact that they learn the phonetic cues more easily than the control cues confirms that they are using phonetic information. Nevertheless, it is also clear that their knowledge of the words' meanings plays some role, even at this very early stage of reading development. Developmentally, the relative role of semantic and phonological information in the acquisition of word reading skills appears an important area for further study.

## 2.6 Summary and Conclusions

This study examined the processes involved in early word learning. The results replicate and extend the findings of Rack et al.(1994). As in this previous study children in the very early stages of reading development were shown to learn printed cues which were phonetically similar to target words than cues which were phonetically dissimilar. This finding suggests that these children are sensitive to the relationship between letters and sounds even when they are unable to use this information in conscious decoding, suggesting that children may access this information earlier than has previously been assumed in some models of reading development. Furthermore, they are able to access much smaller units of phonology than suggested by performance in metacognitive phonological awareness tasks, suggesting that a distinction should be drawn between the phonological representations themselves and the ability to consciously reflect upon and manipulate them. This study has also shown that the rate of learning in the cue learning task is strongly related to phonological awareness measures, in particular to phonemic awareness, which in many ways may be considered the measure of phonological awareness most likely to reflect the quality of the underlying phonemic representations relevant to this task.

These findings have been interpreted within a connectionist framework in which learning to read is viewed as the establishment, in parallel, of connections between orthography and phonology and orthography and semantics. The role these two influences play at different stages of learning to read and the way in which they interact deserves further investigation.

# Chapter Three

# The Influence of Imageability and Regularity on Early Word Learning

## 3.1 Overview

Experiment 1 showed that children in the very early stages of reading development are sensitive to the phonological information in a word and use this information when learning to read. The ease with which the beginning readers were able to learn to read a set of words was also shown to be influenced by their knowledge of the meaning of the words. Children were better able to learn to read words whose meanings they knew than words whose meanings they did not know. This chapter considers two possible influences on early word learning, one phonological and one semantic. Experiments examining the extent to which the imageability and regularity of words influences the ease with which beginning readers will learn to read them are presented in this chapter.

## 3.2 Introduction

As discussed in Chapter 1, there is some evidence that children's ability to read words is influenced by the semantic quality of the word, in particular, its imageability. Imageability refers to the extent to which a word evokes a visual image. A number of studies have also suggested that children's early word learning is influenced by imageability (Kiraly & Firlong 1974; Yore & Ollila 1985). However, the findings of these studies are limited in a number of ways. Firstly, both studies used a very small number of items. Secondly, as discussed in Chapter 1, they did not control for grammatical class. The high-imageability words were all nouns whereas the low-imageability words were all non-nouns, therefore it is possible that the results showed a grammatical bias rather than an imageability effect. Thirdly, these 'learning studies' did not control for the effects of age of acquisition. As some studies looking at the word recognition and lexical processing of older children have suggested that imageability effects disappear when differences in the age of acquisition of words are taken into account, it would seem important to consider this variable as a possible influence on children's early word learning.

Experiment 1 showed that children's ability to learn to read a set of words is influenced both by the phonological quality of the word and the individual child's phonological skills. If children are sensitive to the phonological quality of the word in this way, it is quite possible that they will be influenced by the regularity of the words they are learning. Few studies have considered the ease of learning to read regular and irregular words, although there is some evidence that children's speed and accuracy in recognising words is influenced by regularity (Backman, Bruck, Hebert & Seidenberg, 1984; Olson, Kliegel, Davidson & Foltz, 1985). Rack, Hulme, Snowling & Wightman (1994) investigated the ability of very young children to learn to read 'transparent' and 'opaque' words. Transparent words contained letters which all corresponded to a sound in the word's pronunciation and the sound represented by each letter corresponded to the most frequent or typical sound for that letter in English. The opaque words contained at least one letter that did not correspond to a sound in the word's pronunciation or contained a letter that was assigned an atypical or low-frequency pronunciation. Children's ability to learn to read 24 words differing in their transparency was investigated. The words did not differ in their familiarity, concreteness, imageability, or age-of-acquisition. The children were taught the words over three consecutive days.

It was found that children were able to learn the transparent words significantly more easily than the opaque words. These findings suggest that children in the early stages of learning to read learn to pronounce words with a direct relationship between their spelling and their sound more easily than words where this relationship does not stand. The children in this study were unable to decode even simple CVC non-words therefore the effect of transparency cannot be due to letter-sound decoding. Rack et al. suggest that these findings provide support for their 'direct mapping' hypothesis, and that children in the early stages of reading development are able to generate and use partial phonological information in learning to read a set of words.

The findings described above suggest that children's ability to learn to read words may be influenced by both the imageability and the regularity of the words to be learnt. However, the influence of imageability is as yet unclear given the problems of the studies described here. Furthermore, although there is some suggestion that early word learning is influenced by the phonological regularity of a word, the evidence is scarce and has not been well replicated.

A further consideration is the possible interaction between these two variables. It has been suggested that a division of labour exists between phonology and semantics such that when phonological translation is most difficult the influence of the semantic quality of a word is at its greatest (Plaut, McClelland, Seidenberg &

Patterson, 1996; Strain, Patterson & Seidenberg, 1995). Strain et al. (1995) found that the word recognition of adults showed strong imageability effects only when the words were low frequency exception words. However, no one has considered the possible interaction between imageability and regularity in children's early word learning. It might be predicted, however, that children will show a stronger imageability effect when learning to read irregular words.

## 3.3 Experiment 2

### 3.3.1 Introduction

This experiment was designed to investigate whether children's ability to learn to read a set of words is influenced by the regularity and the imageability of the words to be learnt, and the extent to which these variables may interact with each other in influencing word learning. Thirty-two words were used in the experiment. Four groups of words were created; high-imageability regular words, high-imageability irregular words, low-imageability regular words, low-imageability irregular words. In order to control for any possible influence of age-of-acquisition the groups of words were matched on this variable.

### 3.3.2 Method

#### 3.3.2.1 Participants

Thirty eight children, 22 boys and 16 girls from a primary school in Cardiff took part in the experiment. The children were all in their first year of primary education, 17 came from a mixed reception/year one class, the remaining 21 came from a single entry reception class. The mean age of the children in the experiment was 5 years 4 months (range 4 years 10 months to 5 years 9 months).

#### 3.3.2.2 Design and Materials

The children in this experiment were given a number of tasks, measuring their phonological, semantic and reading skills, their performance in these tasks was related to their ability to learn to read a set of words. The reading and phonological measures used were the same as those used in Experiment 1. They are listed below and described fully in Chapter 2. The semantic measures, which were not used in Experiment 1, are listed and described in detail below.

#### 3.3.2.2.1 Measures of Reading and Phonological Awareness Skills

**(i) BAS Single Word Reading Test** This was the same reading test as used in Experiment 1. Testing is discontinued after 10 consecutive errors.

**(ii) Phoneme Deletion Test** This was the same phoneme deletion test as used in Experiment 1 and was taken from the Phonological Abilities Test (Muter, Hulme & Snowling, 1997). The maximum possible score in the test is 16.

#### 3.3.2.2.2 Measures of Semantic Skill

**(i) Vocabulary Test** The vocabulary sub-test from the Wechsler Pre-school and Primary Scale of Intelligence - Revised (WPPSI-R) was given. This test includes 3 picture items in which the child is required to point to the picture which represents a target word, and 22 verbal items in which the child is required to offer a definition of the target word. The items increase in difficulty. The picture items are scored 1 (correct) or 0 (incorrect). The verbal items are scored 0, 1, or 2 according to the response given. Scores are given according to strict criteria given in the manual in which examples of responses are listed and scored. Testing is discontinued if the child makes 5 consecutive errors. The maximum score possible is 47.

**(ii) Similarities Test** A second sub-test from the WPPSI-R was used, the 'similarities' test. This test contains three parts which have different modes of presentation and require different types of response from the child. There are 6 picture items in which the child is required to choose from a series of pictures the one object that is similar to the objects in another array. There are 6 sentence completion items in which the child is required to provide a word to complete a sentence in a way that shows understanding of the similarity concept indicated in the main body of the sentence. Presentation is oral. Finally, there are 8 verbal analogy items. In this part of the test the child tells how two orally presented concepts are similar. The picture items are scored 1 or 0 and the remaining items are scored 1, 2 or 0. The maximum score for the Similarities test is 28.

**(iii) Synonym Judgement Test** A test of synonym judgement was also devised. This test is made up of 4 practice items and 12 test items all of which are orally presented. The child is asked to say whether two words mean the same or different things. The test items are scored 1 or 0 and the maximum possible score is 12.

#### 3.3.2.2.3 The Experimental Task

Each child was taught a series of words over four consecutive days. Thirty two words were taught in four blocks of eight. The words differed in both their regularity and their imageability. Imageability was rated by 19 individuals all of whom were professionals working with young children. Imageability was defined as the extent to which a word 'can evoke an image in your mind' or 'evokes a clear picture in your mind'. Raters were asked to rate the imageability of a list of words for a young child on a scale of 1-7 where 1 represents extremely low-imageability. The familiarity of the words for the average 5 year old was also rated. Raters were asked to rate words on a scale of 1-5 on the extent to which a young child would have heard a word and would know the meaning of it. Age of acquisition was rated using a 1-7 scale with each point on the scale representing the average age at which a word is acquired by a child. The inter-rater reliability for these ratings was calculated and was found to be high; for familiarity ratings, Alpha= .85, for imageability ratings, Alpha= .98 and for age of acquisition, Alpha= .94.

The same 'transparency' criterion that Rack et al. used was used to choose 'regular' and 'irregular words'. As suggested in the Introduction, transparent, or regular words contain letters which all corresponded to a sound in the word's pronunciation and the sound represented by each letter corresponds to the most frequent or typical sound for that letter in English. The opaque, or irregular words contain at least one letter that does not correspond to a sound in the word's pronunciation or contain a letter that has an atypical or low-frequency pronunciation.

The means for all these ratings were calculated and words were selected for inclusion in the experiment on this basis. For the purposes of this experiment high-imageability is defined as $<5.1$ and low-imageability is defined as $>3.6$. The words were grouped according to regularity and imageability with age of acquisition, familiarity, number of letters and the number of phonemes in each word being controlled for. Four word groups were created; high-imageability regular words, high-imageability irregular words, low-imageability regular words, low-imageability irregular words. There were 8 words in each group. The properties of the words included in these groups is presented in the table 3.1. The words in each of these categories are listed in Table 3.2.

**Table 3.1**

Mean ratings of the items used in Experiment 2

| | imag. | age/acq. | famil. | letters | phoneme | syllables |
|---|---|---|---|---|---|---|
| hi.reg. M | 5.8 | 2.25 | 3.9 | 5.5 | 4.6 | 1.8 |
| SD | .41 | .59 | .48 | .92 | 1.2 | .71 |
| hi.irreg. M | 5.9 | 2.1 | 4.2 | 5.5 | 4.12 | 1.5 |
| SD | .38 | .50 | .43 | 1.41 | 1.45 | .53 |
| low reg. M | 2.05 | 3.06 | 3.75 | 5.87 | 4.75 | 1.5 |
| SD | .69 | .42 | .74 | 2.10 | 1.83 | .93 |
| low irreg M | 2.18 | 2.9 | 3.5 | 5.75 | 4.25 | 1.7 |
| SD | .66 | .67 | .69 | 1.75 | 1.16 | .76 |

These mean ratings were analysed in order to determine that the items in each condition of the experiment did not differ on any of these variables. Separate one way analysis of variance using each variable and condition type as the factors was undertaken. These analyses showed that the item conditions did not differ in their familiarity ($F(3,31)=2.78$, $p>.05$), in their age of acquisition ($F(3,31)= 3.1$, $p=.05$), in the number of letters ($F(3,31)= .07$, $p>.05$) and phonemes ($F(3,31)=.61$, $p>.05$) in each word, or in the number of syllables ($F(3,31)= .22$, $p>.05$).

**Table 3.2**

High-imageability Regular Words

| | Familiarity | Imageability | Age of Acq. | Letters | Phonemes | Syllables |
|---|---|---|---|---|---|---|
| rabbit | 4.3 | 6.4 | 1.5 | 6 | 5 | 2 |
| garden | 4.5 | 6.1 | 1.6 | 6 | 5 | 2 |
| flag | 3.3 | 5.9 | 3.2 | 4 | 4 | 1 |
| doctor | 4.1 | 5.8 | 2.1 | 6 | 5 | 2 |
| sheep | 3.9 | 6.2 | 2 | 5 | 3 | 1 |
| shell | 3.3 | 5.7 | 2.6 | 5 | 3 | 1 |
| button | 4.5 | 6.1 | 1.8 | 6 | 5 | 2 |
| hospital | 3.7 | 5.1 | 2.5 | 8 | 8 | 3 |

**Table 3.3**

High-imageability Irregular Words

| | Familiarity | Imageability | Age of Acq. | Letters | Phonemes | Syllables |
|---|---|---|---|---|---|---|
| knife | 4.6 | 6.4 | 1.8 | 5 | 3 | 1 |
| biscuit | 4.8 | 6.4 | 1.3 | 7 | 7 | 2 |
| knee | 4.3 | 5.8 | 2.1 | 4 | 2 | 1 |
| giant | 3.9 | 6.1 | 2.4 | 5 | 5 | 2 |
| castle | 3.7 | 6.1 | 2.6 | 6 | 5 | 2 |
| fruit | 4.2 | 5.8 | 2.1 | 5 | 4 | 1 |
| lamb | 4.1 | 6.4 | 2.1 | 4 | 3 | 1 |
| building | 3.5 | 5.2 | 2.9 | 8 | 6 | 2 |

**Table 3.4**

Low-imageability Regular Words

| | Familiarity | Imageability | Age of Acq. | Letters | Phonemes | Syllables |
|---|---|---|---|---|---|---|
| strong | 3.9 | 3.9 | 2.4 | 6 | 5 | 1 |
| different | 3.6 | 2 | 2.8 | 9 | 7 | 3 |
| find | 3.8 | 1.7 | 2.4 | 4 | 4 | 1 |
| think | 3.5 | 2 | 3.3 | 5 | 4 | 1 |
| please | 4.6 | 1.4 | 1.3 | 6 | 4 | 1 |
| part | 2.9 | 2 | 3.4 | 4 | 3 | 1 |
| true | 3.2 | 1.6 | 3.6 | 4 | 3 | 1 |
| brilliant | 3.7 | 2.1 | 3.2 | 9 | 8 | 3 |

**Table 3.5**
Low-imageability Irregular Words

| • | Familiarity | Imageability | Age of Acq. | Letters | Phonemes | Syllables |
|---|---|---|---|---|---|---|
| front | 3.9 | 3.1 | 2.3 | 5 | 4 | 1 |
| favourite | 4.1 | 2.6 | 2.3 | 9 | 5 | 3 |
| once | 3.3 | 1.7 | 2.9 | 4 | 3 | 1 |
| break | 3.7 | 3 | 2.4 | 5 | 4 | 1 |
| because | 3.7 | 1.6 | 2.7 | 7 | 5 | 2 |
| guess | 2.9 | 1.5 | 3.4 | 5 | 3 | 1 |
| calm | 2.5 | 2.2 | 4.3 | 4 | 3 | 1 |
| trouble | 3.8 | 2.8 | 2.7 | 7 | 5 | 2 |

All the children were tested before the experimental task began to ensure that they were not already able to read any of the words, no child was able to read more than 1 word in the study.

The words were randomly assigned to one of four groups of words to be learnt over four days. Each word group contained two high-imageability regular, two high-imageability irregular, two low-imageability regular and two low-imageability irregular words. Each child was taught each of these word groups over four consecutive days. The order presentation of each of these groups was counterbalanced.

### 3.3.3.3 Procedure

The language tasks were administered first. Each child was seen for about 20 minutes and given each of the tasks described in the previous section. The children were seen individually in a quiet area of the school library.

For the experimental task the children were again seen individually in a quiet area. The child was told that they were going to learn to read some new words. The child was shown each word on a (12cm x 7cm) card with the word printed in the centre of the card. The card remained in view for 5 seconds while the experimenter gave the word orally and the child repeated it once. If the child failed to produce the word the experimenter told them the correct response. When all the cards had been presented in this way they were shuffled and shown to the child who was required to read the word on the card. If the child refused or gave an incorrect response the experimenter supplied the correct pronunciation for the word. The words were presented 6 times and responses were scored 1 or 0. The total possible score in each of the four word groups was 48, the total possible for the high and low-imageability groups was 96 for each group.

### 3.3.4 Results

The results of the learning task are presented first. The mean number of words learnt in each word category is presented in Table 3.6. Standard deviations are given in brackets.

**Table 3.6**

Mean number of words learnt in each of the word categories

| | **High Imag** | **Low Imag** |
|---|---|---|
| **Regular** | 30.8 (11.7) | 15.7 (13.7) |
| **Irregular** | 30.6 (11.6) | 18.4 (12.7) |

Max poss score in each group= 48

The mean number of high-imageability words learnt over the two regularity conditions was 61.4 (22.8) and the mean number of low-imageability words learnt was 33.4 (25.4). The maximum possible score for each was 96. A large difference in children's performance with high and low-imageability words can be seen, with children learning more high-imageability words than low-imageability words. The mean number of regular words, over both imageability conditions was 46.5 (24.34) and the mean number of irregular words was 49 (23.10 ). This suggests that, if anything, irregular words were learnt more easily than regular words.

The data were subjected to a two-way within subjects analysis of variance in which the within subject factors were Imageability (high or low) and Regularity (regular or irregular). A strong main effect of imageability was found, ($F(1,37)=171.4$, $p<.001$). There was no main effect of regularity ($F(1,37)=3.3$, $p=0.7$). A significant regularity by imageability interaction was found, ($F(1,37)=4.5$, $p<.05$). However, this interaction is in the opposite direction than might be expected with irregular low-imageability words being learnt more easily than regular low-imageability words. No regularity effect is seen with the high-imageability words.

The data were analysed across items as well as across subjects. The item means for each of the word groups are presented in Table 3.7

**Table 3.7**

Item means for each condition

| | High Imag | Low Imag |
|---|---|---|
| **Regular** | 3.73 (0.75) | 2.17 (0.92) |
| **Irregular** | 3.77 (0.88) | 2.48 (0.61) |

A strong main effect of imageability across items was found, (F(1,31)=25.3, p<.001). There was no significant effect of regularity (F(1,31)=.38, p>.05) and no significant regularity by imageability interaction, (F(1,31)=.23, p>.05). These results confirm a strong influence of imageability on word learning in these beginning readers but suggest that regularity, as defined here does not appear to influence early word learning word learning. The marginally significant influences of regularity in the by-subjects analysis can be considered a function of particular words within the item set rather than a robust effect.

### 3.3.4.1 Further Examination of Regularity Effects

The lack of regularity effect found in this study was in some ways surprising because previous studies have shown that children, even at this very early stage of reading development, find regular words easier to learn than irregular words (Rack et al 1994). In order to consider whether this lack of regularity effect was the result of their lack of reading experience a subgroup analysis was done. Two subgroups were formed, the ten best readers (with a BAS score of 13 or more) formed one group and the ten worst readers (with a BAS score of 3 or less) formed a second group. The 'best reader group' has a mean BAS score of 18.20 (5.55) and the 'worst reader group' had a mean BAS score of .80 (1.03). The pattern of results was very similar for both of these groups. There was a large difference in performance between the high and low-imageability words and very little difference between regular or irregular words. The means are presented in Table 3.8 below.

**Table 3.8**

Table showing performance of subgroups

| | hi.reg | hi.irreg | lo.reg | lo.irreg |
|---|---|---|---|---|
| best | 43.5 (5.1) | 42.2 (6.4) | 30.4 (11.7) | 34.1(8.2) |
| worst | 21.1(8.6) | 20.5 (10.8) | 7.6 (6.7) | 9.3 (7.1) |

Table 3.4 suggests that both the best reader group and the worst reader group showed strong imageability effects but no regularity effect. A three-way analysis of variance confirmed a strong main effect of imageability ($F(1,18)=91.5$, $p<.001$) but no effect of regularity ($F(1,18)=.1.2$, $p>.05$) and no significant regularity by imageability interaction ($F(1,18)=.2.84$, $p>.05$). A main effect of group was found ($F(1,18)= 49.22$, $p<.001$), suggesting a difference between the good and poor readers. However, the interactions between group and imageability ($F(1,18)= .53$, $p>.05$) and group and regularity ($F(1,18)= .17$, $p>.05$) were not significant. These results confirm that the regularity of a word, as measured here, does not influence the ease with which it will be learnt by children in the very early stages of reading development.

#### 3.3.4.3 The Relationship between Word Learning and Language Skills

The relationship between performance on the language tasks and the ability to learn to read the words in the experiment was examined. The scores on each of these language tasks are presented in Table 3.9. It can be seen from Table 3.9 that there were no floor or ceiling effects in performance on each of these tasks.

**Table 3.9**

Mean Scores on the Language Tests

| | Mean | SD |
|---|---|---|
| 1.BAS | 8.18 | 7.24 |
| 2.Phoneme deletion | 4.5 | 5.67 |
| 3.Syn. Judgement | 8.68 | 2.37 |
| 4.Similarities | 14.66 | 4.34 |
| 5.Vocabulary | 15.55 | 3.52 |

Max possible scores; 1=90, 2=16, 3=12, 4=28, 5=47

Correlations between the language measures and performance in the word learning task were calculated. The correlations are presented in Table 3.10.

**Table 3.10**

The Correlations between Language Measures and Learning

| | age | vocab | BAS | simil. | phondel | syn j. | hi.imag | lo.imag |
|---|---|---|---|---|---|---|---|---|
| age | | | | | | | | |
| vocab | .06 | | | | | | | |
| BAS | .41** | .41** | | | | | | |
| simil. | .16 | .43** | .51** | | | | | |
| Phondel. | .22 | .45** | .57** | .39** | | | | |
| syn j. | .20 | .34** | .28 | .18 | .26 | | | |
| hi.imag | .25 | .48** | .78** | .38** | .54** | .32* | | |
| lo.imag | .20 | .46** | .81** | .49** | .47** | .26 | .88** | |
| total | .23 | .47** | .82** | .45** | .51** | .30 | .96** | .97** |

* = <.05, ** = <.01

KEY: Vocab= vocabulary, BAS= single word reading, simil.= similarities, phondel= phoneme deletion, syn.= synonym judgement, hi.imag= high-imageability score, lo.imag= low-imageability score

It is clear that almost all of the language measures correlate strongly with performance on the learning task. The ability to learn to read the words is strongly related to vocabulary, similarities, phoneme deletion, and reading ability. It is slightly less strongly related to performance in the synonym judgement task. It is interesting that the measures of semantic skill are so strongly related to the ability to learn to read these words; although most models have focused on the role of phonological factors, it is clear that these semantic factors are also involved in early word learning.

A series of regression analyses were conducted in order explore the extent to which the language measures could account for performance in the word learning task. The total learning score, that is the total number of words learnt, regardless of imageability and regularity was taken as the dependent variable. In a hierarchical regression, age and the BAS single word reading score were entered first and accounted for a large amount of the variance in the total score (68.9%, p<.001). After these factors had been controlled for, the language measures were entered into the equation.

The results of this analysis show that none of the language measures account for variance in word learning scores after reading skill (BAS) and age have been controlled. However, this result may be unsurprising given that age and reading ability together accounted for such a high proportion of the variance in the word learning scores.

**Table 3.11**

Summary of hierarchical regression using total learning as the dependent variable

| STEP | VARIABLE | % VARIANCE |
|---|---|---|
| 1. | BAS & Age | 68.9%** |
| 2. | Phoneme Deletion | 0.3% |
| 3. | Similarities | 0% |
| 4. | Synonym Judgement | 0.5% |
| 5. | Vocabulary | 1.4% |

Given the very strong correlation between reading skill (BAS) and learning in this task, further regression analyses omitting reading skill from the model were conducted. The total learning score was again used as the dependent variable and the independent variables; phoneme deletion, vocabulary, similarities, and synonym judgement were entered in all possible positions. The results of this analysis are presented in Table 3.12.

When a regression analyses is done without the BAS single word reading score three of the four variables account for significant variance when entered on the first step; Phoneme Deletion (26.5%, p<.05), Vocabulary (23%, p<.05), and Similarities (20.4%, p<.05). Performance on the Vocabulary sub-test was shown to account for significant variance after Phoneme Deletion scores were accounted for but ceased to account for significant variance once performance on the Similarities and Synonym Judgement task have been taken into account. Performance on the Similarities sub-test no longer accounted for significant variance once Vocabulary was entered. Phoneme deletion is the only variable to account for significant variance on the third step (10.7%, p<.05) and, furthermore, accounts for marginal significance when entered on the final step (6.9%, p<.07)), suggesting some independent contribution of phoneme deletion scores in predicting learning performance. The contribution of each of the variables is shown in Table 3.12.

**Table 3.12**

Summary of hierarchical regression with total learning score as the dependent variable

| STEP | VARIABLE | % VARIANCE |
|---|---|---|
| 1. | Phoneme Deletion | 26.5** |
| 2. | Vocabulary | 0.7 |
| 3. | Similarities | 3.8 |
| 4. | Synonym Judgement | 0.9 |

| STEP | VARIABLE | % VARIANCE |
|---|---|---|
| 1. | Similarities | 20** |
| 2. | Synonym Judgement | 4.9 |
| 3. | Phoneme Deletion | 10.7* |
| 4. | Vocabulary | 3 |

| STEP | VARIABLE | % VARIANCE |
|---|---|---|
| 1. | Vocabulary | 23* |
| 2. | Similarities | 7.4 (p=.06) |
| 3. | Synonym Judgement | 1.7 |
| 4. | Phoneme Deletion | 6.9 (p=.06) |

| STEP | VARIABLE | % VARIANCE |
|---|---|---|
| 1. | Synonym Judgement | 8.8 |
| 2. | Phoneme Deletion | 20.5* |
| 3. | Vocabulary | 5.9 |
| 4. | Similarities | 3.8 |

### 3.3.5 Discussion

Experiment 2 examined the influence of imageability and regularity on the ability of beginning readers to learn to read a series of words. It was shown that these young children learned to read high-imageability words much more easily than low-imageability words. This was the case when both age of acquisition and familiarity were controlled for, confirming that any advantage of high-imageability words was not due to these factors. The finding that children in the very early stages of reading development are influenced by the semantic quality of the words they are learning, is somewhat surprising. Most models of reading development have focused on the importance of phonological factors, arguing that a word must be recognised first before any influence of semantics can come into play. The findings of this experiment suggest that the semantic quality of a word may influence the ease with which a word is recognised from a very early stage. However, one problem with this experiment is that it still fails to control for grammatical class. The high-imageability words in this experiment are all nouns, whereas the low-imageability words come from a number of grammatical categories. It is, therefore still possible that the effects of imageability are mediated by effects of grammatical class.

Experiment 2 suggested that the ease with which words are learnt in the early stages of reading development is not influenced by the regularity of the words. Regular words were not learnt any more easily than irregular words. The fact that a regularity effect was not found in Experiment 2 may be due to a number of factors. Firstly, some would argue that children in this very early stage of reading development would be most influenced by the salient features of the words they were learning, and that regularity would be unlikely to play a role until a later stage when a decoding mechanism had developed. However, the results of Experiment 1 and those of Rack et al. (1994) suggest that children do use some phonological information from words before they are able to decode even simple words and that phonological processes operate in the development of word recognition skills from a very early stage. Secondly, it may be that the results differed from those of Rack et al. because the children in this study were in some way different to those studied by Rack et al. It is the case that the children in Experiment 2 were younger than those seen by Rack et al. Finally, it is possible that the difference between these two studies reflect differences between the words used. In order to investigate these possibilities further the Rack et al. study was replicated.

## 3.4 Experiment 2(b) Replicating the Rack et al. study

### 3.4.1 Introduction

It is possible that these children were not finding regular words easier to learn, as had been found in the Rack et al. (1994) study because their reading ages were slightly lower than those in the Rack et al study. To test this hypothesis a replication of the Rack et al study was undertaken. The Rack et al. study had involved teaching 15 children with a mean age of 5 years, 2 months (range 4 years, 7 months to 5 years 7 months) to read 24 nouns which differed in their transparency.

### 3.4.2 Method

#### 3.4.2.1 Participants

Thirteen children, from the school where the present study took place, took part in the replication. The mean age of the children was 5 years, 6 months and their mean reading age was 5 years, 6 months, which is slightly older than the children in the Rack et al study. The children were able to read a mean number of 13.46 (10.33) words from the BAS single word reading test. It was therefore reasoned that if the lack of a regularity effect in Experiment 2 were due to the fact that the children were younger and were reading at a much lower level, a regularity effect would be observed in these older children.

#### 3.4.2.2 Design and Materials

Exactly the same items and procedure as in the Rack et al study were used. The children were taught 24 words on three successive days and asked to recall the words over 5 trials. The words are listed in Table 3.13 below. The words were closely matched on rated age-of acquisition, frequency, concreteness, imageability, number of letters and number of phonemes. Values for these variables came from the Oxford Psycholinguistic Database (Quinlan, 1992). The characteristics of these words are shown in Table 3.14.

**Table 3.13**

Words used in the Rack et al. (1994) study

| *Opaque Words* | *Transparent Words* |
|---|---|
| march | watch |
| forest | giant |
| hotel | dungeon |
| garden | biscuit |
| flag | salt |
| basket | bomb |
| elbow | island |
| sand | pigeon |
| snake | honey |
| nose | fruit |
| jacket | knife |
| beef | knee |

**Table 3.14**

Characteristics of the Transparent and Opaque Words used by Rack et al.

| | letters | phons. | freq. | conc'ness | a.o.a | imag. |
|---|---|---|---|---|---|---|
| Transparent | 5 | 4.33 | 4.86 | 597 | 253 | 592.8 |
| Opaque | 5.33 | 4.17 | 44.3 | 580 | 261 | 592.9 |

KEY: phons= no. of phonemes, freq.= frequency rating, conc'ness= concreteness rating, aoa= age of acquisition rating, imag= imageability rating

### 3.4.2.3 Procedure

Following Rack et al., the 24 words were divided into three groups of eight, each containing four transparent and four opaque words. Children were tested over three consecutive days and were taught one of each of these word sets on each of the days. The order of presentation of the sets of words was counterbalanced. The children were shown the words, printed on cards. The experimenter pronounced the word. The children were shown each card in a random order for 5 trials.

## 3.4.3 Results

Rack et al. found a significant difference between the learning of transparent words and the learning of opaque words ($t(14)= 5.48$, $p<.001$). However, the children in this experiment do not appear to learn transparent and opaque words any differently. Table 3.15 compares the mean learning scores of the present experiment with those of Rack et al. (1994). The mean 'transparent score' in the present study was 50.3 (18.31) and the mean 'opaque score' was 50.3 (15.85), however, three children were scoring very close to ceiling and therefore were removed from the analysis. The means shown below therefore are for the remaining 10 children

**Table 3.15**

Comparing the learning of transparent and opaque words across experiments

| | Transparent | Opaque |
|---|---|---|
| Rack et al. | 34.2 (14.06) | 24.4 (13.68) |
| Experiment 2 (b) | 44.8 (17.25) | 44.7 (13.58) |

### 3.4.4 Discussion

It can be seen that the young children in this study did not find transparent words easier to learn to than opaque words. This confirms the findings of Experiment 2, discussed above and suggests that the lack of regularity effect seen in that experiment was not simply due to the fact that the children in Experiment 2 had a lower reading age than the children in the Rack et al. study. It is not clear why the children in the Rack et al. study should show a regularity effect in their word learning while the children in this experiment do not, however, the findings here question the validity of the Rack et al. findings.

One possibility is that the children in the present study were performing at a much higher level overall and that this might explain the fact that the regularity effect found by Rack et al. is not found here. However, it was also the case in the previous experiment that children performing at a much lower level also failed to show regularity effects. Another possibility is that the words themselves in these experiments may not be irregular enough in order to produce a replicable regularity effect. It is clear from the results of Experiment 1 that children at this very early stage of reading development are able to use partial phonological information from a word to form connections between the printed and its spoken forms of a word. It is possible that some of the items in Experiments 2 and 2(b) are learnt in the same way and that this masks any possible regularity effect. The children in these studies are not yet able to decode even simple CVC words and so it is possible that they are not influenced by a large part of the word, if some letters in the word are regular enough to support connections then it is possible that the irregular part may be over-looked. For example, consider the 'irregular' word *biscuit*, although the vowel sounds in this word are irregular, the consonants are regular and may be enough to support word recognition. It is possible that *bsct* is enough of a cue to support the word being learnt. This possibility is considered further in Chapter 5.

### Summary and Discussion

It can be concluded from Experiment 2 that the imageability of a word has a strong influence on the ease with which beginning readers learn to read it. However, it is not clear from Experiment 2 is whether this imageability effect is confounded with grammatical class. The spelling-to-sound regularity of words, as measured in

Experiments 2 and 2(b) does not appear to influence how easily children learn to read them, although as suggested above there are a number of reasons why this effect may not have been found. Given that no regularity effect was found it is impossible to consider any possible interaction between the phonological and semantic qualities of a word and how this might influence word learning.

## 3.5 Experiment 3

### 3.5.1 Introduction

Experiment 3 was designed to consider whether the imageability effects found in Experiment 2 were due to a grammatical bias in learning to read words, rather than due to the influence of imageability. In Experiment 3 the ability of young children to learn to read a series of words which differed in their imageability, but not in their grammatical class, was investigated. It was thought impossible to find enough low-imageability nouns that 4-5 years olds would be reasonably familiar with and therefore the words in Experiment 3 are all verbs.

### 3.5.2 Method

#### 3.5.2.1 Participants

Twenty children, 11 girls and 9 boys took part in study six. Four children came from a Year One class and sixteen from a reception class. The children came from schools in and around the York area. The mean age of the children was 4 years, 9 months (range 4 years, 1 month to 5 years, 8 months).

#### 3.5.2.2 Design and Materials

The design of this experiment was very similar to that of Experiment 2. The participants were taught to read a series of words over two consecutive days. Half the words were of high-imageability and half were of low-imageability. All the words included in this study were verbs or words which are predominantly used as verbs.

Prior to being taught the words the BAS Word Reading Test was administered and letter knowledge was tested. Sixteen words were included in the study and two forms of the experiment were created. In each form eight words, four of high-imageability and four of low-imageability, were learned over three consecutive days. Imageability was rated by 14 individuals all of whom were professionals working with children the age of those included in this study. The familiarity and age of acquisition of the words was also rated. The inter-rater reliability of these ratings was measured and was found to be high; for age of acquisition, Alpha=.78, for familiarity, Alpha=.86, for imageability, Alpha=.96. The familiarity and age of acquisition of the words was controlled for across the two groups of words to be learnt. The mean imageability, age of acquisition and familiarity ratings for the words is presented in Table 3.16. The words used in Experiment 3 are listed in Table 3.17 and 3.18.

**Table 3.16**

Characteristics of the words used in Experiment 3

| | Imag | Age of Acq | Famil. | Letters | Phonemes |
|---|---|---|---|---|---|
| high imag | 2.4 | 3.4 | 4.2 | 3.8 | 3.1 |
| low imag | 5.5 | 3.4 | 4.2 | 3.8 | 3.1 |

**Table 3.17**

High-imageability Words

| | Imageability | Age of Acq. | Familiarity | Letters | Phonemes |
|---|---|---|---|---|---|
| read | 5.7 | 3.7 | 4.7 | 4 | 3 |
| dance | 6.1 | 3.8 | 3.7 | 5 | 4 |
| jump | 6.2 | 3 | 4.5 | 4 | 4 |
| eat | 6.1 | 2.2 | 5 | 3 | 2 |
| push | 4.6 | 3 | 4.3 | 4 | 3 |
| bake | 4.8 | 4.5 | 3.3 | 4 | 3 |
| dig | 5.5 | 3.3 | 3.6 | 3 | 3 |
| sing | 5.3 | 3.3 | 4.7 | 4 | 3 |

**Table 3.18**

Low-imageability Words

| | Imageability | Age of Acq. | Familiarity | Letters | Phonemes |
|---|---|---|---|---|---|
| come | 1.9 | 2.3 | 4.7 | 4 | 3 |
| put | 2.1 | 3.3 | 4.2 | 3 | 3 |
| have | 2.2 | 3.5 | 4.3 | 4 | 3 |
| stay | 2.4 | 3.8 | 3.6 | 4 | 3 |
| find | 3.3 | 3.1 | 4.1 | 4 | 4 |
| tell | 3.3 | 3.7 | 4.1 | 4 | 3 |
| wait | 1.8 | 4 | 3.5 | 4 | 3 |
| take | 2.8 | 3.4 | 4 | 4 | 3 |

The rating scores were subjected to analysis of variance in order to determine that the groups of words did not differ in their familiarity, age of acquisition or in their number of letters and phonemes. The analysis showed that the word groups differed in their imageability ($F(1,15)=103.9$, $p<.001$) but not in their familiarity ($F(1,15)=.40$, $p>.05$), age of acquisition ($F(1,15)=.01$, $p>.05$), number of letters ($F(1,15)=<1$, $p>.05$) or number of phonemes ($F(1,15)=<1$, $p>.05$).

All the words included in the study have both a verb sense and a noun sense, the verb sense being predominant in all cases. This was considered to be particularly the case for the average 5 year old child. However, to check that the children considered these words primarily as verbs, after learning them they were asked to form a sentence for each of the words.

#### 3.5.2.3 Procedure

Each child was seen individually on three occasions. The reading and letter knowledge test were administered in the first session. The child was then told that they were going to learn to read some new words. The children were shown each word printed on a 12 cm x 7 cm card. The word remained in view for about 5 seconds while the experimenter pronounced the word and the child repeated it once. Eight words, four high-imageability and four low-imageability, were presented. When all the cards had been presented in this way they were shuffled and shown to the child again who was asked to recall the word. The words were presented for recall 6 times and scored 1 or 0. If the child refused or gave an incorrect response the experimenter supplied the correct pronunciation for the word. The same words were presented 6 times on the following day and 6 times on the third day. The total possible score for each word group (high vs. low-imageability) was 72.

### 3.5.3 Results

The children in this study were able to read an average of 1.5 (3.55) words on the BAS single word reading test, and knew on average 17.4 (6.74) letters of the alphabet. The mean number of words they learnt from each of the word categories is presented in Table 3.19.

**Table 3.19**

Mean Number of High and Low-imageability Words Learnt

| Words | mean | std. dev. |
|---|---|---|
| high-imageability | 39.9 | 22.95 |
| low-imageability | 22.95 | 20.29 |

Max poss score in each word group is 72

A large difference in the children's ability to learn high and low-imageability verbs can be seen, with children learning more high-imageability verbs than low-imageability verbs.

The data was subjected to analysis of variance in which the within subject factor was Imageability (high or low). A strong main effect of imageability was found, ($F(1,19)=73.42$, $p<.001$). The data was also analysed across items. The high-imageability item mean was 9.57 (2.06) and the low-imageability item mean was 5.5 (1.59). A strong main effect of imageability across items was found, ($F(1,15)=19.67$, $p=.001$). These results confirm a strong influence of imageability on word learning when age of acquisition, familiarity and grammatical class are controlled for.

As discussed above, the words included in this study may be used as both nouns and verbs but the prominent usage for each of the words is as a verb. To confirm that this was also the case for the young children in this study the children were asked to create a sentence for each of the words. Each word was learnt by 10 children meaning that 10 sentences were created for each word. No sentence was created using the target word as a noun rather than a verb except for one child who produced the sentence 'you stand on the weighter' for the target word 'wait'. Four of the words, jump, put, take and sing produced one 'no response' each. It is clear then that the target words in this experiment were understood predominantly as verbs by the children attempting to learn to read them. This is important because it can be claimed with more certainty that imageability influences early word learning of verbs as well as of nouns and adjectives.

### 3.5.4 Discussion

It can be seen from the results of Experiment 3 that the imageability of a word influences the ease with which it will be learnt regardless of the grammatical class from which it comes. This confirms that effects of imageability are not due to a bias towards learning words from a particular grammatical category more easily than words from another category. The fact that age of acquisition was controlled for in this experiment also rules out the possibility that the imageability effect reflects differences in the age of acquisition between high and low-imageability words. Although this experiment does not provide an answer to the question of why imageability should influence the ease with which children learn to read a word, it does suggest that it is not due to a bias towards words from a certain grammatical category. This finding can be related to the model of semantic representation discussed in Chapter 1. Plaut & Shallice (1993) propose that word meanings are represented in terms of distributed features and that any advantage for particular types of words, e.g. high-imageability words, comes from the fact that these words are represented by a larger number of features and that the correlations between the features are stronger. This model has no place for a grammatical bias in word recognition, words are recognised purely as a function of activation at a featural level. Activation is determined by the number of features or the density of features in a word's semantic representation.

## 3.6 General Discussion

The experiments in this chapter were designed to investigate whether children in the very early stages of reading development are influenced by the semantic factor, imageability and the phonological factor, regularity. The results show that children are influenced by the imageability of a word when they are learning to read it, and that this influence remains even when age-of-acquisition, familiarity, number of letters and phonemes and grammatical class are controlled for. However, regularity, as measured here, did not influence the ease with which words are learnt. These results are different from those of Rack et al. (1994) who found that transparency had a strong influence on word learning. Experiment 2(b) confirmed that the fact that no regularity effect was found in the present experiment is not due to the fact that the children studied by Rack et al. were older and better readers.

These findings question the validity of the effect found by Rack et al. However, this does not mean that children will not be influenced by the regularity of a word at all when attempting to learn it. As suggested in Section 3.4.4, one possibility is that the extent to which 'irregular' words may be harder to learn to read may depend on where in the word the irregularity lies. It is proposed that irregular consonants may influence learning more than irregular vowels, because consonants may be more salient in forming partial cues between printed words and their spoken pronunciation. This possibility is considered further in Chapter 5. Because regularity was not shown to influence the ability of young children to learn to read a set of words, it was not possible to consider the interaction between phonological and semantic factors in early word learning. However, Experiment 1 did demonstrate that children are influenced by the phonological quality of the words they are learning from a very early stage. It remains possible that phonological and semantic processes have interactive effects in children's early reading acquisition. This issue of a possible interaction will be investigated further in future chapters.

Experiments 2 and 3 both showed a strong influence of imageability on early word learning, with children learning high-imageability words more easily than low-imageability words. As suggested above, the fact the children at this very early stage of reading development are influenced by the semantic quality of a word is somewhat surprising given current models of reading development. Stage models emphasise the role of salient visual features having the strongest influence on reading at this stage (Frith, 1985). Others have shown that children are influenced by the phonological character of words from an early stage (Ehri & Wilce, 1985; Rack et al. 1994). Most have argued that the development of a phonological pathway is primary at this very early stage of reading development (Plaut et al., 1996). While it is certainly the case that children need to develop some phonological skills before they are able to access the word and therefore be influenced by the semantic quality of the word, it is also clear that semantic factors play a role from the start. This process could be considered in terms of the connectionist models of word recognition outlined in Chapter 1. If both semantic and phonological factors are represented as distributed features, it is possible that activation across both these sets of units could play a part in learning to associate a printed word with its spoken pronunciation from a very early stage. This possibility will be considered in more detail in future chapters.

It is not clear from the experiments presented in this chapter why imageability should have such an influence on the ability of young children to learn to read a series of words. What has been established however, is that the influence of imageability at this stage of reading development is not attributable to effects of age of acquisition or to a bias towards learning words from a particular grammatical category. It has been suggested that all of these influences may be considered within a connectionist framework in which word meanings are represented in a distributed fashion. Recognition, or learning, according to this approach, is dependent on the level of activation across the features that represent a word. However, the results of Experiments 2 and 3 do not rule out the alternative possibility that part of the advantage seen for high-imageability words is due to their access to an image system as well as a verbal system (Paivio, 1971).

## 3.7 Summary and Conclusions

This chapter has reported three experiments investigating the influence of imageability and regularity on the ability of young children to learn to read a set of words. While some previous studies have attempted to consider the influence of imageability on word learning, these studies were flawed in a number of ways that limited interpretation of their findings. The results presented here clearly show that the imageability of a word influences the ease with which it will be learnt in the early stages of reading development. Furthermore, this influence has been shown when age-of-acquisition, familiarity, number of letters and phonemes, and word form have all been controlled for. This confirms that the effect of imageability is not due to any of these other variables.

Although Experiment 1 has shown that beginning readers were influenced by the phonological quality of the words they were attempting to learn, Experiments 2 and 2(b) failed to show that children were influenced by the regularity of words they are learning to read. Nevertheless, it was shown that individual differences in phonological skills, as measured by a phoneme deletion task were related to the ability to learn to read the words in Experiment 2. One possibility is that the measure of regularity used here is not sensitive enough for children at this very early stage of reading development and that if more strongly irregular or 'exception' words were used an effect would be seen. As no regularity effect was found it was not possible to consider the possible interaction between regularity and imageability. This possible interaction will be considered in Chapter 5.

# Chapter Four

# Examining the Ability of Beginning Readers to Learn to Read Exception Words

## 4.1 Overview

Chapters 2 and 3 provide good evidence that children in the very early stages of reading development are sensitive to phonological information in words when learning to read them. This sensitivity was demonstrated in a cue learning task in which children were taught to associate three letter abbreviated words with spoken target words. The same sensitivity to phonology was not demonstrated as clearly in the learning of real words. It was hypothesised that if children were sensitive to the sound structure of words they learn to read they would find regular words easier to learn than irregular words. Experiments 2 and 2(b) did not find this to be the case. One possible reason for the lack of regularity effect is that the items used in these experiments are not irregular enough. This chapter considers different definitions of regularity in order to re-examine the effects of regularity on word learning.

Chapters 2 and 3 also showed that the semantic quality of words is an important indicator of the ease with which children will learn to read them. Chapter 2 showed that specific knowledge of the meaning of the word to be learnt predicted ease of learning, even after controlling for performance in phonological awareness tasks. Chapter 3 used more general measures of semantic skill and also found a relationship between overall learning and performance in these semantic skills. However, this was not found to be the case once the contribution of phonological skill was taken into account. It is possible that knowledge of the particular word to be learnt is a stronger predictor of learning than general vocabulary skills. This chapter presents two experiments which compare the learning of regular and exception words. Learning is related to performance in a range of language tasks some of which are based on the words the children are taught to read and others are general measures based on other words. The predictive role of these two types of language measure is compared

## 4.2 Introduction

Two issues are examined in this chapter. Firstly, the extent to which the regularity of a word influences the ease with which children learn to read the word is considered. Secondly, the types of phonological and semantic skills which will predict this learning. Experiments 2 and 2(b) investigated the influence of regularity on the word learning of children in the very early stages of reading development. It was argued that if children are sensitive to the phonological structure in the words they are learning, as was suggested by the findings of Experiment 1, then children would find it easier to learn to read regular words than irregular words. However, the results of Experiment 2 and 2(b) did not find this to be the case. It was argued that one possible reason was the definition of regularity used.

As discussed in Chapter 3, few studies have examined the effect of regularity on word learning. However, a number of studies have considered the influence of regularity on children's word recognition. These studies have used a variety of different definitions of regularity and it would seem that the definition used has some influence on the strength of any regularity effect shown. Regularity can be considered in terms of simple grapheme-phoneme correspondences (Venezky, 1970), in terms of the consistency with which segments of a word are pronounced in English (Glushko, 1979) or by the neighbourhood size of a word, i.e. the number of words which differ from the target word by one letter in the same serial position (Laxon, Coltheart & Keating, 1988). Furthermore, regularity can refer to phonological regularity, orthographic regularity, or both phonological and orthographic regularity.

A number of studies have compared the effects of these different forms of regularity on children's word recognition. Laxon, Coltheart & Keating (1988) found that neighbourhood effects were seen before consistency effects in children's reading, furthermore, regularity effects independent from consistency effects were not seen . These findings suggest that children are influenced by the consistency of the spelling patterns in words and by the number of other words sharing the same spelling pattern. Brown & Watson (1994) draw a distinction between neighbours which are 'friends' and neighbours which are 'enemies' and suggest a developmental difference in the extent to which these influence children's reading. They found that younger children were influenced by the number of enemy neighbours a target item had, i.e. how irregular it was, and became increasingly influenced by the number of friends the target word had. It would seem that children are increasingly able to use helpful spelling sound constraints as their reading develops. It is possible that this is due to an increasing sight vocabulary allowing an increasing awareness of the friends available. Clearly, children are influenced by regularity in their reading but the way in which regularity is defined is important in determining the strength of the regularity effect and furthermore, the influence of regularity may change with development.

The influence of regularity on learning to read novel items is not well established. Rack et al. (1994) investigated early word learning by comparing the learning of 'transparent' and 'opaque' words. Transparent words were defined as words containing letters which all corresponded to a sound in the word's pronunciation and where the sound represented by each letter corresponded to the most frequent or typical sound for that letter in English. Opaque words contained at least one letter that did not correspond to a sound in the word's pronunciation or contained a letter that was assigned an atypical or low-frequency pronunciation. Rack et al. found that beginning readers learnt to read transparent words more easily than opaque words. However, the same definition of regularity was used in Experiment 2 and no effect of regularity was found, furthermore, Experiment 2(b) was a direct replication of the Rack et al. study and this also failed to find an effect of regularity on early word learning.

It was suggested in Chapter 3 that one reason why regularity was not seen to influence word learning might have been the definition of regularity used. Some models of reading development would predict that no effect of regularity would be found. For example, traditional stage models would argue that children at this very early, pre-alphabetic, stage of reading development would not show a regularity effect because they would not be influenced by phonological information in the word. Such models would suggest that children's learning of words would be driven primarily by whole word features, visually salient cues or word length (Frith, 1985). However, Experiments 1-3 demonstrated that children are able to use some phonological information from a very early stage of reading development. Ehri (1992) argues that children will use partial phonological cues to aid word learning from an early stage. Similarly, as discussed in Chapters 1 and 2, Rack et al. (1994) propose a direct mapping mechanism by which children set up connections between phonology and orthography from the start of reading development. This 'direct mapping mechanism' also relates to the Seidenberg & McClelland (1989) connectionist model of reading development. It was argued in Chapter 3 that consonants, particularly consonants in boundary positions in a word, are used first in forming these connections between print and spoken pronunciation, therefore, it would seem likely that the regularity of these consonants would be of particular importance in word learning. A number of studies have considered children's reading errors and have concluded that consonants, particularly when these are the boundary letters of words are more accurately represented than vowels (Fowler, Shankweiler & Liberman, 1979; Stuart & Coltheart, 1988; Ehri, Wilce & Taylor, 1987 ). As suggested in Chapter 3, one reason why a regularity effect may not have been found is that in most of the items to be learnt the consonants were regular, therefore allowing the children to use this partial information to form connections between the printed word and its spoken pronunciation and therefore learn to read the word. It is argued that children at this very early stage of reading development may only access partial phonological information from a word and therefore may not attend to a large part of the word's phonology. It was hypothesised that if a word's irregularity lay particularly in the consonants, this would impede learning and a regularity effect would be seen. An experiment is presented in this chapter in which the learning of regular and irregular words is compared. The items included in this experiment all have irregular consonants.

A second aim of this chapter is to consider the extent to which a variety of language measures can predict children's ability to learn to read the words in the experiment. Experiments 1-3 included a variety of background measures which, to varying extents were able to predict word learning. Experiment 1 showed that phonological skills were important in early word learning, with phonemic awareness being a particularly strong predictor. Children's knowledge of the meaning of the words to be learnt was also a strong predictor of their learning. Experiments 2 and 2(b) also found phoneme awareness to be a strong predictor of learning. However, although performance in a standardised vocabulary test was related to learning it was not as strong a predictor as the phoneme awareness measures. It is possible that this discrepancy between the predictive value of semantic knowledge in these two studies lies in what might be refereed to as their specificity of prediction. In Experiment 1 the vocabulary measure was based on the child's ability to define the actual words they were to learn, whereas in Experiment 2 the vocabulary measure was not based on any of the words to be learnt. It is reasonable to expect that tasks based on the specific words to be learnt in the experiment will be stronger predictors of the rate of learning to read those words than more general measures of semantic ability. This may be particularly the case for semantic measures. It has already been shown that general phonological skills predict learning, it is possible, however, that the relationship between learning to read a set of words and semantic skills is a more specific relationship and is to do with a representation of the specific word to be learnt. The representation of phonology may be considered to be based on more consistent rules than the representation of semantics. Experiments 4 and 5 in this chapter consider whether language tasks based on the words to be learnt are stronger predictors of subsequent learning than tasks based on a general selection of words.

## 4.3 Experiment 4

### 4.3.1 Introduction

As outlined above, this experiment was designed to investigate the influence of regularity on children's ability to learn to read a set of words. The definition of regularity used here is different from that used in Experiments 2 and 2(b). The items used in the present experiment all contained irregular consonants. It is argued that consonants, particularly those in boundary positions in words, are particularly important in this stage of reading development in that they enable children to form connections between the printed and spoken form of words. It is therefore predicted that words containing irregular consonants will be more difficult to learn than regular words.

The ability of a range of phonological and semantic measures to predict performance on the word learning task was also examined. Some of these measures were standardised measures and some were based on the words to be learnt in the experiment. An important aim of the experiment was to assess whether these measures based on the Experiment 1 items were stronger predictors of learning than the standardised measures.

### 4.3.2 Method

#### 4.3.2.1 Participants

Twenty children, 11 girls and 9 boys took part in the experiment. Fourteen of the children had taken part in a previous experiment and six of the children had not. The children all came from the same primary school in York. Ten of the children came from the reception class and ten from the year one class. The mean age of the children was 5 years, 5 months (range 4 years, 6 months to 6 years, 1 month).

#### 4.3.2.2 Design and Materials

Most of the children had been tested on a number of language tasks, 3 months previously (time 1), as part of another experiment. However, because some of the children were performing at ceiling on a pre-test for the present experiment they were excluded from this study and 6 new children joined the study. These six children were given the above tests at the start of Experiment 4 (time 2).

#### 4.3.2.2.1 Time 1 Measures

**(i) BAS Single Word Reading** Reading was assessed using the British Ability Scales single word reading test (Elliot, Murray & Pearson, 1983). This test is described fully in Chapters 2 and 3.

**(ii) Graded Nonword Reading Test** Decoding skills were measured using the same nonword reading test that was used in Experiments 1, 2 and 3 (Snowling, Stothard & McClean, 1996).

**(iii) Letter Knowledge** Letter knowledge was assessed by asking children to name or give the sound of each of the letters of the alphabet presented in a random order.

**(iv) Phonological Awareness Measures** Two measures of phonological awareness from the Phonological Abilities Test (Muter, Hulme & Snowling, 1997) were given. The rhyme detection task and the phoneme deletion task described in Chapters 2 and 3 were used.

**(v) Semantic Measures** As in Experiment 2 the vocabulary sub-test from the Wechsler Pre-school and Primary Scale of Intelligence-Revised (WPPSI-R) was administered. This test is described fully in Chapter 3. A semantic production task was also given in which the child is required to generate as many words as possible in a given category, e.g., 'food', 'transport' within a 30 second time limit.

#### 4.3.2.2.2 Time 2 Measures

A number of semantic and phonological tasks were devised using the actual words that the children were required to learn.

***(i) Phonological Tasks***

Rhyme:

The children were asked to produce as many words or nonsense words they could to rhyme with each of the words in the experiment. Two practice items were given and then the target words were presented in a fixed order, the same for each child, with 20 seconds allowed to produce rhymes for each word.

Phoneme Deletion:

In this task the child was required to delete the beginning phoneme from each of the target words. Two practice items were given and the child was told that they had to say the word without saying the named sound.

Segmentation:

In this task the child was asked to complete part of the word after the examiner had started it, so if the target word was 'river' and the examiner said 'ri...' the child would be required to reply 'ver' to finish the word off. Some of the target words were two syllable words and some were one syllable words and therefore not all the words were segmented at the syllable division.

### *(ii) Semantic Tasks*

Definition:

Participants were asked to define each of the twenty words and the responses were recorded. The responses were scored 0, 1 or 2 points each giving a maximum possible of 40 points.

Associations:

Participants were asked to produce as many semantically related words to the target words as possible. The children were given twenty seconds per word to think of as many words as possible that 'go with' the target word.

Sentence Verification Task:

A number of sentences were presented to each child and the child was asked to state whether it was a 'good sentence' or a 'silly sentence'. Each target word appeared in a good and a silly sentence. The two sentences were similar in structure but differed only in relation to one or two words which altered the sense of the sentence by correct or incorrect use of the target word. For example for the target word 'sword' the good sentence was 'The king killed the dragon with his sword' and the silly sentence was 'The king cleaned the dragon with his sword'. The 40 sentences were presented in random order so the child was not required to hold two sentences in memory and choose between the two. A point was scored if both sentences for each target word correctly identified, this gave a total possible score of 20.

#### 4.3.2.2.3 The Experimental Task

The aim of Experiment 4 was to teach these beginning readers to read a series of words that differed in their regularity. Twenty words were used. These words were rated, as in previous experiments, for imageability, familiarity and age of acquisition by 16 professionals used to working with children in this age range. Inter-rater reliability was examined and was found to be high; for imageability, Alpha= .92, for age of acquisition, Alpha= .90, and for familiarity, Alpha= .90. There were two types of word used in this experiment, highly regular words and exception words. Imageability, familiarity and age of acquisition were controlled for across both word conditions.

The regular words were all words which contained regular, consistent letter-sound correspondences. The irregular words were exception words which contained irregular, inconsistent letter-sound correspondences. The irregularity in these words was always in the consonants of the word as it was reasoned that it is these irregularities that make direct mapping so difficult. The properties of these two groups of words, based on the ratings collected are shown Table 4.1. The items used in experiment 4 are shown in Tables 4.2 and 4.3.

**Table 4.1**

The properties of words in the two word groups

| | Famil. | Imag. | Age/Acq. | Letter | Phoneme | Syllable |
|---|---|---|---|---|---|---|
| Exception | 3.12 | 4.63 | 3.13 | 5.5 | 3.5 | 2.0 |
| SD | 0.9 | 1.2 | 3.13 | 5.5 | 3.5 | .47 |
| Regular | 3.33 | 4.51 | 3.05 | 5.5 | 4.7 | 1.4 |
| SD | 0.6 | 1.4 | 0.6 | 0.7 | 0.8 | .52 |

In order to examine whether the word groups differed on each of these characteristics the data were subjected to analysis of variance. This analysis showed that the word groups did not differ in their imageability ($F(1,19)= .04, p>.05$), in their age of acquisition ($F(1,19)= .06, p>.05$), in their familiarity, ($F(1,19)= .33, p>.05$), or in their number of letters ($F(1,19)= .00, p>.05$). However, the regular words had slightly more phonemes ($F(1,19)= 12.2, p<.05$) and syllables ($F(1,19)= 5.8, p<.05$). The fact that the regular words contained slightly more letters and phonemes than the exception words would make the regular words more difficult, rather than easier to learn than the exception words and therefore this is not a problem for the experiment.

**Table 4.2**

Irregular Words used in Experiment 4

| | Famil | Imag. | Age/acq. | Letters | Phoneme | Syllable |
|---|---|---|---|---|---|---|
| ocean | 2.7 | 4.8 | 3.8 | 5 | 4 | 2 |
| island | 2.6 | 4.2 | 3.7 | 6 | 3 | 2 |
| sword | 3.2 | 5.9 | 3.1 | 5 | 3 | 1 |
| comb | 3.9 | 5.9 | 2.3 | 4 | 3 | 1 |
| choir | 1.6 | 3.2 | 4.3 | 5 | 4 | 1 |
| laugh | 4.6 | 3.8 | 2.2 | 5 | 3 | 1 |
| iron | 2.8 | 4.4 | 3.6 | 4 | 3 | 1 |
| daughter | 2.5 | 2.7 | 3.7 | 9 | 4 | 2 |
| ceiling | 3.1 | 4.9 | 2.8 | 7 | 5 | 2 |
| thumb | 4.3 | 6.5 | 1.9 | 5 | 3 | 1 |

**Table 4.3**

Regular Words used in Experiment 4

| | Famil. | Imag. | Age/ac. | Letter | Phoneme | Syllable |
|---|---|---|---|---|---|---|
| robber | 3.2 | 5.5 | 3 | 6 | 4 | 2 |
| cotton | 2.7 | 4 | 3.6 | 6 | 4 | 2 |
| lucky | 3.2 | 2.3 | 3.7 | 5 | 4 | 2 |
| basket | 3.5 | 5.9 | 2.6 | 6 | 6 | 2 |
| silver | 2.5 | 3.8 | 3.5 | 6 | 5 | 2 |
| winter | 3.4 | 3.9 | 3.3 | 6 | 5 | 2 |
| visit | 3.1 | 2.5 | 2.9 | 5 | 5 | 2 |
| river | 3.7 | 5.7 | 2.9 | 5 | 4 | 2 |
| flag | 3.3 | 5.9 | 3.3 | 4 | 4 | 1 |
| animal | 4.7 | 5.7 | 1.6 | 6 | 6 | 3 |

#### 4.3.2.3 Procedure

All 20 participants were pre-tested on the regular and irregular words to see if they were already able to read them. Six of the children who had taken part in a previous experiment were able to read a substantial number of them and so were dropped from the study. Six younger children who were unable to read any of the target words replaced them. The background measures were administered as above for the six children who had not taken part in the previous experiment.

The children were told that they were going to learn to read some new words. The children were seen individually in a quiet area outside the class room. They were shown each word separately, printed on a card, in a random order. On the first showing of the card the examiner told the child what the word was, the child was then required to repeat the word. The card remained in view for 5 seconds. The cards were then shuffled to randomise the order of presentation. The cards were then presented to the child again and they were asked if they knew what the word was. The words were then shuffled and shown a further three times. Each target word was therefore given 4 trials. Testing took place over three consecutive days. On the second and third day the participants were shown the same words for four trials and asked to recall the word. Each word was seen in total 12 times and scored 0 or 1, giving a total possible score for each item of 12 and for each condition, 120. The children were then shown these words once more approximately one week after they had originally been taught the words and asked if they could again recall them. This gave a total possible score for each condition of 10.

After the three days of learning these words the participants were given the other language tasks which used the words they had been learning. The participants were given these tests over two consecutive days, in the following fixed order;

1. definitions
2. rhyme
3. segmentation
4. associations
5. sentence verification
6. phoneme deletion.

### 4.3.3 Results

#### 4.3.3.1 Comparing the Learning of Regular and Exception Words

The mean performance with each of the word types is presented below. There were ten words in each condition and each word had been given 12 trials over four days, this gave a maximum possible score of 120 for each condition.

**Table 4.4**

Mean scores (and std. deviations)of the two age groups

| | Regular | Irregular |
|---|---|---|
| **Reception** | 51.3 (27.8) | 35.8 (28.5) |
| **Year 1** | 92.2 (18.4) | 64.6 (25.6) |

The data were subjected to analysis of variance in which the within subject factor was Condition (regular or exception) and the between subject factor was Age Group (reception or year one). There was a strong main effect of condition ($F(1,18)=44.31$, $p<.001$) and a strong main effect of age group ($F(1,18)=10.23$, $p<.05$). The age group by condition interaction was not significant, although there was a trend in this direction, ($F(1,18)=3.49$, $p=.07$). The Year 1 children do appear to be more influenced by regularity than the reception children. The mean difference between scores for the regular and exception words was 28 for the older children and 15 for the younger children.

The data were analysed across items as well as across subjects. The mean scores for each item group are presented in Table 4.5. A strong main effect of condition across items was found ($F(1,39)=14.45$, $p<.001$) and a strong main effect of age group across items was found ($F(1,39)=40.23$, $p<.001$). There was no significant age by condition interaction ($F(1,39)=.92$, $p>.05$). These results confirm the findings of the subject analysis in suggesting an influence of regularity on word learning in beginning readers. The results of the item analysis do suggest, however, that the trend towards an age by condition interaction in the subject analysis is not a robust one.

**Table 4.5**

Item means for each condition

| | Mean | Std. Dev. |
|---|---|---|
| **Regular** | 7.14 | 1.56 |
| **Exception** | 4.99 | 1.73 |

#### 4.3.3.2 Delayed Recognition of the Words Learnt in Experiment 4

The children were also tested on the words approximately one week after they had originally been taught them. This time the words were shown only once and so the maximum possible score is 20 overall, 10 for the regular words and 10 for the irregular words. The mean number of words read one week after initial exposure was 12.7. The means for words in each condition are presented below.

**Table 4.6**

Number of Words Learnt after a One Week Delay

| | Regular | Exception |
|---|---|---|
| Reception | 5.1 (2.4) | 3.6 (2.3) |
| Year 1 | 8.9 (1.2) | 7.8 (1.79) |

The data from the delayed recall were also subjected to analysis of variance. A main effect of condition (F(1,18)=22.2, p<.001) and a main effect of age group (F(1,18)=18.45, p<.001) was found. As in the immediate recall condition, no age by condition interaction was observed (F(1,18)=.53, p>.05). These findings suggest that children's long term learning of words is also influenced by the regularity of the words they are learning.

#### 4.3.3.3 The Relationship between Learning and the Language Tasks

The ability to learn to read the words was related to performance in the language tasks. The mean performance in all the language tasks given at time 1 is presented in Table 4.7 and performance in tasks given at time 2 is presented in Table 4.8.

**Table 4.7**

Mean scores on tasks administered at Time one

| **Time 1 Tasks** | **Mean** | **Std. Dev.** |
|---|---|---|
| Rhyme | 6.8 | 2.91 |
| Vocabulary | 19 | 5.99 |
| Semantic Production | 22.5 | 5.3 |
| Nonword reading | 1.6 | 2.62 |
| BAS Reading | 6.4 | 6.21 |
| Letter Knowledge | 21 | 4.86 |
| Phoneme Deletion | 4.75 | 5.3 |

**Table 4.8**

Mean Scores on Tasks administered at Time 2

| **Time 2 Tasks** | **Mean** | **Std. Dev.** |
|---|---|---|
| Definitions | 26.1 | 5.9 |
| Rhyme | 40.1 | 23.3 |
| Sentence Verification | 12.1 | 3.46 |
| Associations | 24.3 | 12.2 |
| Segmentation | 14.5 | 3.09 |
| Phoneme Deletion | 7.1 | 6.56 |

The tables above show that the children were not performing at ceiling or at floor in any of the language tasks. The relationship between performance in these tasks and the ability to learn to read the words in the experiment was examined. Correlations between overall learning, i.e. learning to read the words regardless of regularity, and performance in the language tasks were calculated. These correlations are shown in Table 4.9 below. The left-hand column shows the simple correlations and the right-hand column shows partial correlations, controlling for age. A distinction is made between 'general' and 'specific' measures, the specific measures are those tasks based on the words in the experiment, the general measures are based on words not in the experiment.

**Table 4.9**

Correlations between language tasks and overall learning

| TASKS | r | partial r |
|---|---|---|
| BAS Single word reading | .80** | .72** |
| Nonword Reading | .41 | .09 |
| Letter Knowledge | .72** | .56* |
| Rhyme - General | .48* | .22 |
| Rhyme - Specific | .33 | .21 |
| Phoneme Deletion - General | .48* | .41 |
| Phoneme Deletion - Specific | .65* | .62* |
| Segmentation - Specific | .45* | .37 |
| Semantic Production - General | .02 | .06 |
| Associations - Specific | .42 | .38 |
| Sentence Verification - Specific | .36 | .26 |
| Vocabulary - General | .19 | .14 |
| Definitions - Specific | .40 | .22 |

It can be seen from Table 4.9 that the ability to learn to read the words is strongly related to performance in the single word reading test, in the 'general' rhyme test, in the phoneme deletion test, in the segmentation task based on the words to be learnt and to letter knowledge. Some of these correlations cease to be significant once age is controlled for, however, single word reading, letter knowledge and performance in the phoneme deletion task based on the words in the experiment, remain significant. These correlations show a similar pattern as in Experiments 1 and 2 in suggesting a strong relationship between learning and phonemic awareness. None of the semantic tasks in this experiment correlated significantly with word learning, although the correlation with performance in the 'associations' task is marginally significant (.42, $p<.07$).

In order to explore the extent to which performance in these language tasks could account for variance in the word learning task a series of regression analyses was conducted. In the first analyses the total word learning score (irregular + exception score) was taken as the dependent variable. In a hierarchical regression, age and the BAS single word reading score were entered first and accounted for a large amount of variance in the total score (71.7%, $p<.001$). After these factors had been controlled for, the general phonological and semantic measures were entered into the equation at steps 2-7.

**Table 4.10**

Summary of hierarchical regression using total learning as the dependent variable and the general measures as independent variables

| STEP | VARIABLE | %VARIANCE |
|---|---|---|
| 1. | Age, BAS | 71.7%** |
| 2. | Rhyme | 0 |
| 3. | Vocabulary | 6.3* |
| 4. | Semantic Prod. | 0 |
| 5. | Nonword | 0.4 |
| 6. | Letter Knowledge | 6.7* |
| 7. | Phoneme Deletion | 4 (p<.06) |
| 2. | Vocabulary | 5.2 |
| 3. | Semantic Prod | 0 |
| 4. | Nonword | 0 |
| 5. | Letter Knowledge | 7* |
| 6. | Phoneme Deletion | 4 |
| 7. | Rhyme | 1.4 |
| 2. | Semantic Prod. | 0.2 |
| 3. | Nonword | 0.3 |
| 4. | Letter Knowledge | 8.3* |
| 5. | Phoneme Deletion | 5.9* |
| 6. | Rhyme | 0 |
| 7. | Vocabulary | 2.8 |
| 2. | Nonword | 0 |
| 3. | Letter Knowledge | 6.3* |
| 4. | Phoneme Deletion | 6.2* |
| 5. | Rhyme | 0 |
| 6. | Vocabulary | 4 (p<.06) |
| 7. | Semantic Prod. | 0.7 |
| 2. | Letter Knowledge | 6.7* |
| 3. | Phoneme Deletion | 4.8* |
| 4. | Rhyme | 0 |
| 5. | Vocabulary | 2.2 |
| 6. | Semantic Prod. | 0.6 |
| 7. | Nonword | 3.1 |
| 2. | Phoneme Deletion | 6.8* |
| 3. | Rhyme | 0 |
| 4. | Vocabulary | 2.5 |
| 5. | Semantic Prod. | 0 |
| 6. | Nonword | 2.1 |
| 7. | Letter Knowledge | 6.1* |

It can be seen that once age and performance on the BAS has been taken into account the remaining variables do not account for a great deal of the variance in overall learning. Only letter knowledge accounts for any significant unique variance once all the variables have been accounted for, although the contribution of the phoneme deletion measure is close to significance. The extent to which the 'specific' measures of phonology and semantics, i.e. those based on the words in the experiment, could account for variance in overall learning was examined in a second regression equation. Given the significant contribution of letter knowledge in the above analysis, it was also included in this second analysis. Table 4.11 shows the contribution of each of the variables when entered on the final step.

It can be seen from Table 4.11 that phoneme deletion is the only variable to account for any unique significant variance in the overall learning score. None of the other variables had a unique significant effect. Of particular interest here was whether measures based on the actual words to be learnt were stronger predictors of learning than measures based on other words. In order to examine this a further regression analyses was undertaken in which the contribution of phoneme deletion based on general and phoneme deletion based on specific words was compared. Age and BAS single word reading score were entered into the equation first and then letter knowledge and the phoneme deletion measures were entered. The results of this analysis is presented in Table 4.12.

**Table 4.11**

Summary of hierarchical regression using total learning as the dependent variable and the specific measures as independent variables

| STEP | VARIABLE | %VARIANCE |
|---|---|---|
| 1. | Age, BAS | 71.7%** |
| 2. | Definitions | 6.3* |
| 3. | Rhyme | 0.1 |
| 4. | Sentences | 2 |
| 5. | Associations | 4.4 |
| 6. | Segmentation | 0.6 |
| 7. | Phoneme Deletion | 6* |
| 8. | Letter Knowledge | 0.2 |
| 2. | Rhyme | 1.2 |
| 3. | Sentences | 0 |
| 4. | Associations | 8* |
| 5. | Segmentation | 1.9 |
| 6. | Phoneme Deletion | 8.1** |
| 7. | Letter Knowledge | 0.2 |
| 8. | Definitions | 0.2 |
| 2. | Sentences | 0 |
| 3. | Associations | 9.2* |
| 4. | Segmentation | 1.9 |
| 5. | Phoneme Deletion | 6.8** |
| 6. | Letter Knowledge | 0.4 |
| 7. | Definitions | 0.2 |
| 8. | Rhyme | 1.1 |
| 2. | Associations | 7.6* |
| 3. | Segmentation | 2.4 |
| 4. | Phoneme Deletion | 7.1** |
| 5. | Letter Knowledge | 0.6 |
| 6. | Definitions | 0 |
| 7. | Rhyme | 1.3 |
| 8. | Sentences | 0.5 |
| 2. | Segmentation | 6.4* |
| 3. | Phoneme Deletion | 10.3** |
| 4. | Letter Knowledge | 0.3 |
| 5. | Definitions | 0.1 |
| 6. | Rhyme | 1.2 |
| 7. | Sentences | 0.2 |
| 8. | Associations | 1.2 |
| 2. | Phoneme Deletion | 16.7*** |
| 3. | Letter Knowledge | 0.3 |
| 4. | Definitions | 0.1 |
| 5. | Rhyme | 1.2 |
| 6. | Sentences | 0.2 |
| 7. | Associations | 1.2 |
| 8. | Segmentation | 0 |
| 1. | BAS&Age | 71.7** |
| 2. | Letter Knowledge | 6.7* |
| 3. | Definitions | 3.5 |
| 4. | Rhyme | 0 |
| 5. | Sentences | 0.5 |
| 6. | Associations | 4.0 |
| 7. | Segmentation | 0 |
| 8. | Phoneme Deletion | 4.9* |

*=p<.05, **=p<.01, ***p<.001

**Table 4.12**

Summary of hierarchical regression with total learning score as the dependent variable

| STEP | VARIABLE | %VARIANCE |
|---|---|---|
| 1. | Age, BAS | 71.7%** |
| 2. | Letter Knowledge | 6%* |
| 3. | Phon. Del. - general | 4.8%* |
| 4. | Phon. Del. - specific | 5.4%* |
| 3. | Phon. Del. - specific | 10.3%* |
| 4. | Phon. Del. - general | 0% |

It can be seen from Table 4.12 that the phoneme deletion measure based on the actual words to be learnt in Experiment 4 is a better predictor of the ease with which the words will be learnt than the phoneme deletion measure based on general words.

### 4.3.4 Discussion

The results of Experiment 4 showed that children in the very earliest stages of reading development learn to read regular words more easily than irregular words. Unlike Experiment 2, in which an effect of regularity on learning was not observed the words in the present experiment were predominantly irregular in terms of their consonants rather than their vowels. It is argued that children represent consonants more consistently than vowels and that consonants, particularly those in boundary positions, are important in forming connections between the printed and spoken form of words. Therefore consonantal irregularities are particularly problematic for children at this stage of reading development. Contrary to the predictions of traditional stage models it would seem that children are sensitive to phonological information in the early stages of learning to read. This provides support for the findings of Experiment 1 which found that children were sensitive to phonological information when learning to associate three letter abbreviations with target words.

The results of Experiment 4 do not indicate which level of regularity the children are sensitive to. As discussed in the Introduction, studies of children's word recognition have suggested that children are sensitive to the consistency of the word body and to the number of neighbourhood enemies, and later friends, an item has. However, these factors were not controlled for in the present experiment and so it is not clear what level of irregularity is influencing children's learning. However, it is argued that children in this very early stage of reading development will not be sensitive to any of these levels of irregularity. It is unlikely that children in this stage of reading development would be influenced by the number of neighbours a word has because they have not developed an adequate sight vocabulary for any degree of interference or facilitation to be observed. The children in this experiment were unable to decode even simple CVC words therefore it is unlikely that they would be influenced by the regularity of a word defined in terms of simple grapheme phoneme correspondences. These children are unable to decode in a left to right manner, instead it is argued that when they learn to read these words they do so by some form of a direct mapping mechanism. As suggested by Ehri (1992) and Rack et al. (1994) children in this stage of reading development are able to use partial phonological information from the word in order to set up direct connections between phonology and orthography. This implies that every letter in a word will not necessarily be processed but that two or three letters, particularly those in salient positions in the word may be enough to form a connection between the printed word and its spoken form. According to this model of reading development, it would be predicted that children at this stage of reading development would be influenced by the regularity of words they are learning to read but only when the irregularity occurred with the letters most important in forming these early connections between print and the spoken form.

It is important to note that the regularity effect remained when the children were tested one week after they had initially been taught to read the words. Firstly, this finding adds to the robustness of the findings that regularity influences word learning. Secondly, the fact that such an effect is seen after a time delay adds credence to the claim that the task in this, and other experiments, is indeed analogous to the way in which children learn to read words in a more naturalistic setting. The children in this experiment are setting up connections between print and its spoken form that are maintained beyond the brief time limit of the experiment , and furthermore, are still influenced by the phonological quality of the word.

A second aim of Experiment 4 was to consider the extent to which a variety of phonological and semantic tasks predicted overall word learning. As was found in previous experiments letter knowledge and phoneme deletion were strongly correlated with the ability to learn to read the experimental items. Performance in the semantic tasks was not found to correlate with performance in the word learning task, as was found in Experiments 1-3, although the correlation with performance in the 'associations' task was marginally significant. One possible reason why a relationship between semantic skills and word learning may not have been significant in this experiment is that the measures used were not sensitive enough. The ability to define the words to be learnt was not found to be significantly correlated with performance in the word learning task, as had been found in Experiment 1. One reason why this might be is because of difficulties with scoring the definitions children of this age give. The associations task, which was marginally significantly correlated with overall word learning, is in many ways a better measure of the quality of the children's semantic representations of the words to be learnt. Nevertheless it is clear that there are other cognitive demands of this task. One problem with the presentation of the associations task was that it was always presented after the rhyme production task, as a result many children continued to provide rhyming words in the association task.

Experiment 4 sought to compare the relationship between word learning and performance on language tasks based on words in the experiment and word learning and language tasks based on words not in the experiment. The results with regards to this comparison are not clear. Although it was found that the phoneme deletion measure based on the actual words to be learnt produced a stronger correlation with word learning than the general phoneme deletion measure, it is possible that this is due to the fact that the words to be learnt were more complex than the words in the standardised phoneme deletion task. Part of the difference between the predictive strength of these two tasks may be due to the fact that one phoneme deletion task was simply more difficult than the other. A further problem with comparing these two types of language task is that they were administered on two separate occasions, the standardised 'general' measures were given to the children 3 months earlier than the word learning task, whereas the 'specific' tasks were administered concurrently with the word learning; it is possible, therefore, that any difference between the two types of task is due to this. As a result of these methodological problems it is impossible to reach any firm conclusions about whether language tasks based on the words children are learning to read are stronger predictors of their reading or not. These issues are addressed in Experiment 5.

## 4.4 Experiment 5

### 4.4.1 Introduction

As suggested in the discussion to Experiment 4, a number of methodological problems prevented any firm conclusions being drawn about the way in which performance in a variety of phonological and semantic tasks predict a child's ability to learn to read a set of words. Experiment 5 was devised in order to investigate this issue further. The design of Experiment 5 allowed for a more controlled comparison of tasks based on the words to be learnt with tasks not based on the words to be learnt. All of the children in the experiment did tests based on two lists of words but learnt to read only one list of words. It was hypothesised that performance on the tasks based on the words the children subsequently learnt to read would correlate more strongly with performance in the word learning task than would the tests based on the other words which the children were not required to subsequently learn. The words used in Experiment 5 were the same as those which had been used in Experiment 4 which allowed the comparison of learning regular and irregular words to be repeated.

## 4.4.2 Method

### 4.4.2.1 Participants

Thirty children from the reception classes of two schools participated in this study. The children were all in the final term of their reception year. Twenty one of the children came from a primary school in York and nine of the children from a school in Cardiff. The schools were in similar residential areas and included children from similar backgrounds. The mean age of the children was 5 years 1 month (range 4 years 8 months to 5 years 4 months).

### 4.4.2.2 Design and Materials

#### *4.4.2.2.1 Phonological and Semantic Measures*

The design was similar to that employed in the previous experiment in that the participants were given repeated exposure to a number of words and then later tested to see how many words they had learnt to read. The items to be learnt were the same as those used in Experiment 4. A number of phonological and semantic tasks were devised based on these 20 words in Experiment 4. The same language tasks were used in the present experiment. These tasks are listed below and are described in more detail in Experiment 4. These tasks were administered to all the children in a set order along with a single word reading test and a test of letter knowledge. This took place before the children were 'taught' the words. These tests were administered as follows:

1. BAS single word reading test
2. Letter Knowledge

3. Definitions Test
4. Associations Test
5. Segmentation Task
6. Phoneme Deletion Task
7. Rhyme Task

#### *4.4.2.2.2 The Word Learning Task*

The children were taught to read the same words that had been used in Experiment 4. These were 10 regular and 10 exception words; the word groups did not differ in their rated familiarity, age of acquisition, imageability or in their number of phonemes or letters. In Experiment 5 this list of twenty words was divided into two groups of 10 words, of these ten words, 5 were regular and 5 were exception words. After the children had completed all the language tasks described above they were split into two groups. This meant there were two groups of children, group A and group B, and two lists of words, list A and list B.

It was reasoned that if the specific language measures are more predictive of learning to read the words then measures based on words in list A would be more predictive of learning to read list A than measures based on list B, and vice versa. It was possible to test this hypothesis because all of the participants had done language tasks based on all the words (lists A and B) but had only been taught to read the words from either list A or list B.

In order to ensure that the words in lists A and B were similar in terms of the ease with which they may be defined, segmented, associated and so on, data was used from Experiment 4 to inform the construction of these lists. It was important to ensure that there were no differences between the two lists in terms of performance on the language tasks. As well as being controlled for performance on the above tasks the lists were also controlled for imageability, age of acquisition, familiarity, number of letters and number of phonemes, based on mean ratings collected for Experiment 4. The characteristics of these two word lists are shown in Table 4.13. The words are listed in Table 4.14.

**Table 4.13**

Characteristics of words in Experiment 5

| LIST | fam | imag | age/acq | letter | phon. | assoc | ph.del | seg. | defin |
|---|---|---|---|---|---|---|---|---|---|
| A | 3.2 | 4.5 | 3.1 | 5.5 | 4.3 | 1.32 | .34 | .0 | 1.3 |
| | | | | | | | | | |
| B | 3.2 | 4.6 | 3.1 | 5.5 | 3.9 | 1.12 | .37 | 0.7 | 1.3 |

KEY: fam= familiarity rating, age/acq= age of acquisition rating, phon= no. of phonemes, assoc= mean associations score from experiment 4, ph.del.= phoneme deletion score from experiment 4, seg= segmentation score from experiment4, defin= definition score from experiment 4

**Table 4.14**

Two groups of words used in Experiment 5

| *List A* | *List B* |
|---|---|
| ocean | iron |
| island | thumb |
| comb | robber |
| basket | daughter |
| animal | visit |
| silver | flag |
| winter | lucky |
| choir | ceiling |
| cotton | river |
| laugh | sword |

Item analysis based on scores from Experiment 4 revealed that there were no significant differences between the two groups of words in terms of phoneme deletion ($F(1,19)=.231$, $p>.05$), definitions ($F(1,19)=.110$, $p>.05$), segmentation ($F(1,19)=.1.4$, $p>.05$) and associations ($F(1,19)=1.1$, $p>.05$).

### 4.4.2.3 Procedure

The children were shown these words on two consecutive days. Prior to teaching the children the words each child was given a pre-test to ensure that they were not already able to recognise the words. Most of the participants were unable to read any of the words although 2 of the children could read 2 of the words.

The children were shown the words printed on white card. They were told they were going to learn to read some new words and should look carefully at the word and try and remember what the word said. The words were presented, in a random order, and remained in view while the experimenter told the child the word, the child was then asked to repeat the word. The word remained in view for 5 seconds. The cards were then shuffled and the child was given 6 trials at naming each word. The procedure was repeated on the second day although the child was not told the words again. Errors were corrected, otherwise no feedback was given. In total each word was seen 12 times, giving a maximum possible score for each word of 12 or 120 for all the words. Because half the words being taught were regular and half were exception words it was also possible to replicate the regularity effect found in Experiment 4

### 4.4.3 Results

#### 4.4.3.1 Performance of Group A and Group B

The performance of both groups of children was compared. The means for the background language measures, using the words from both lists, are presented in Table 4.15.

**Table 4.15**

The performance of groups A and B on all the background language measures

| | Group A | Group B | F value |
|---|---|---|---|
| BAS | 7.9 (6.9) | 6.5 (5.2) | 0.42 ns |
| Letter Knowl. | 20.3 (6.1) | 22.3 (5.1) | 0.94 ns |
| Definitions | 24.3 (7.1) | 26.1 (5.8) | 0.58 ns |
| Associations | 20.6 (12.3) | 19.2 (9.5) | 0.13 ns |
| Segmentation | 12.7 (5.7) | 14.1 (5.2) | 0.45 ns |
| Phoneme Del. | 4 (6.35) | 3.9 (6.1) | 0.001 ns |
| Rhyme | 31.2 (20.7) | 32.4 (19.9) | 0.02 ns |

It can be seen from Table 4.15 that both groups of children performed at a similar level in all of the language tasks given prior to being taught to read the words.

Analysis of variance showed that the performance of the groups did not differ from one another on any of the tasks.

The mean number of words learnt over the two days, regardless of regularity, is shown in Table 4.16. Each child learnt either list A words or List B words, each list consisting of 10 words. These words were presented 12 times over 2 days giving a maximum possible score of 120 for all the words. Group B learnt slightly more words than group A, however, this difference is not significant ($F(1,28)=.423$, $p>.05$).

**Table 4.16**

The mean number of words learnt over two days

| | Mean | Std. Dev. |
|---|---|---|
| A | 63.5 | 28.5 |
| B | 70.3 | 28.8 |

#### 4.4.3.2 Comparing the learning of regular and exception words

It was also possible to examine whether the regular words were learnt more easily than the exception words, as was found to be the case in Experiment 4. Each word list contained 5 regular and 5 exception words, presented 12 times each over 2 days, therefore giving a maximum possible score of 60 in each condition. Mean performance for each of the word conditions is presented below, the mean is given firstly for both groups combined (ALL) and then for the two groups separately.

**Table 4.17**

Mean performance with regular and exception words

| Group | | Regular | Exception |
|---|---|---|---|
| ALL | M | 37.3 | 29.6 |
| | SD | 14.9 | 15.3 |
| A | M | 38.2 | 25.3 |
| | SD | 15.2 | 15.8 |
| B | M | 36.4 | 33.8 |
| | SD | 15.08 | 15.3 |

The data was subjected to analysis of variance in which the within subjects factor was Condition (regular or exception) and the between subjects factor was Group (A or B). A strong main effect of condition (F(1,28)=14.4, p=.001) was found, confirming that the regular words were learnt more easily than the exception words. There was no effect of group (F(1,28)=.42, p>.05) although the group x condition interaction did prove to be significant (F(1,28)=6.35, p<.05). The means show that group A showed a stronger regularity effect than group B.

An analysis of variance by items was also completed. The means for each of the item conditions are presented in Table 4.18 below.

**Table 4.18**

Item Means in each of the Conditions

| | Mean | Std. Deviation |
|---|---|---|
| **Regular** | 7.45 | 1.29 |
| **Exception** | 5.99 | 1.29 |

A main effect of condition (F(1,19)=4.8, p<.05), but no effect of group (F(1,19)=.92, p>.05) and no significant condition by group interaction (F(1,19)=2.57, p>.05) was found. Although the subject analysis had shown a significant condition x group interaction this needs to be interpreted cautiously given the small number of words in each condition and the fact that this finding was not found in the item analysis. The item analysis does, however, confirm the finding of Experiment 4, that children in the early stages of reading development find it easier to learn to read regular words than highly irregular or exception words.

#### 4.4.3.3 Examining the relationship between word learning and performance in the language tasks

Part of the aim of this study was to examine the relationship between learning to read words and the language measures taken prior to learning them. One particular aim was to compare the relationship between learning and the language measures based on the words to be learnt and between learning and the language measures based on other words. The mean performance on these language tasks was presented above, below the means of the language tests are presented showing the mean performance with the two word sets separately.

**Table 4.19**

Mean performance of group A in language tasks with words A and B

| | | Mean | Std. Dev. |
|---|---|---|---|
| definitions | A | 11.8 | 3.4 |
| | B | 12.4 | 4.2 |
| associations | A | 11.9 | 7.5 |
| | B | 8.7 | 5.3 |
| segmentation | A | 6.7 | 2.8 |
| | B | 6 | 3.05 |
| phoneme del. | A | 2.06 | 3.4 |
| | B | 1.9 | 3.01 |
| rhyme | A | 14.5 | 10.1 |
| | B | 16.6 | 12 |

**Table 4.20**

Mean performance of group B in language tasks with words A and B

| | | Mean | Std. Dev. |
|---|---|---|---|
| definitions | A | 12.6 | 2.8 |
| | B | 13.9 | 3 |
| associations | A | 11.5 | 6.03 |
| | B | 8.8 | 5.5 |
| segmentation | A | 7.3 | 2.7 |
| | B | 6.8 | 2.6 |
| phoneme del. | A | 1.9 | 2.9 |
| | B | 2.06 | 3.2 |
| rhyme | A | 15.3 | 10.3 |
| | B | 17 | 10.2 |

Table 4.21 shows the correlations between performance in these language tasks and the ability to learn the words. This table shows the relationship between learning and performance on the language tasks combining both sets of words. The remaining tables show the correlations when the language tasks are broken down into performance with list A words and performance with list B words.

**Table 4.21**

The correlations between performance on the language tasks and the ability to learn a set of words.

| | BAS | letter | defin. | assoc. | seg'n | ph.del | rhyme |
|---|---|---|---|---|---|---|---|
| BAS | | | | | | | |
| letter | .73** | | | | | | |
| defin. | .39* | .46* | | | | | |
| assoc | .25 | .13 | .28 | | | | |
| seg'n | .47** | .46** | .34 | .23 | | | |
| ph.del | .83** | .50** | .28 | .32 | .55** | | |
| rhyme | .52** | .39* | .32 | .37* | .53** | .66** | |
| learn | .62** | .73** | .37* | .28 | .21 | .51** | .33 |

*= <.05 **=<.01

It can be seen from Table 4.21 that the ability to learn to read the words is significantly correlated with single word reading, letter knowledge, the ability to define the words, and with phoneme deletion. The correlations between word learning and performance on the associations and segmentation tasks failed to reach significance level.

Table 4.22 below shows the correlations between learning to read the words and performance on the language tasks when the specific language tasks, i.e. tasks based on the words later learnt, and the non-specific language tasks, i.e. tasks based on words other than those later learnt, are considered separately. For group A children, who learnt list A words, the specific language measures are those based on group A words while the non-specific measures are those based on group B words. The extent to which the correlations between specific measures and word learning skill and the non-specific measures and word learning skill differed from one another is also shown in the table.

**Table 4.22**

The Relationship between Word Learning and Specific and Non-specific Language Measures

| | | r | t value (df=27) |
|---|---|---|---|
| Definitions | Specific | .22 | |
| | Non-specific | .42* | 1.2 ns |
| Associations | Specific | .15 | |
| | Non-specific | .29 | 0.83 ns |
| Segmentation | Specific | .26 | |
| | Non-specific | .17 | 0.99 ns |
| Phoneme Del | Specific | .50** | |
| | Non-specific | .46* | 0.36 ns |
| Rhyme | Specific | .37* | |
| | Non-specific | .27 | 0.86 ns |
| BAS Single Word Reading | | .62** | |
| Letter Knowledge | | .73** | |

*= p<.05 **= p<.01

It can be seen from Table 4.22 that none of the specific measures were significantly more strongly related to word learning than the non-specific measures which is not surprising given the relatively small sample size here. However, for some of the measures there was a trend in this direction. Such a trend was found for the rhyme and phoneme deletion measures. The specific rhyme measure predicted word learning while the non-specific measure was not significantly related to word leaning.

The association and segmentation tasks were not significantly related to word learning in either the specific or the non-specific condition, these tasks had also failed to predict word learning in Experiment 4. The definitions task was found to be significantly related to word learning only in the non-specific condition, this finding is contrary to what was expected. One problem with the definitions task was that it was very difficult to score. In Experiment 1 where the ability to define a word was found to be a strong predictor of the ease with which it was read many of the children did not know the meaning of some of the words, in the present experiment most of the children knew something about the word and therefore scoring their responses was much more subtle. The results of this experiment confirm the findings of the previous experiments in suggesting that phoneme awareness and letter knowledge are strong predictors of word learning. Although with some of the tasks used here there is a trend in the direction of specific measures being more strongly related to word learning than non-specific measures, it should be noted that this is only the case for some of the measures and the difference between the size of the correlation coefficient for the two types of measure is small, and non-significant.

### 4.4.4 Discussion

Experiment 5 examined the relationship between performance on a variety of phonological and semantic tasks and the ability to learn to read a set of words. Overall performance on the word learning task was found to be related to letter knowledge, the ability to define the words and to performance in a phoneme deletion task. The relationship between word learning and performance on the 'associations' and rhyme production tasks was not significant.

Although the relationship between the specific language tasks and word learning was not significantly stronger than the relationship between the non-specific language tasks and word learning, this was the case for a few of the measures. The rhyme measure was significantly related to word learning in the specific condition but not in the non-specific condition. Similarly the relationship between the specific phoneme deletion measure and word learning was stronger than the relationship between the non-specific phoneme deletion measure and word learning. Nevertheless, the differences in the strength of the predictive relationship between specific and non-specific language tasks and performance in the word learning task were small. Therefore, it can be concluded that tasks based on the words to be learnt are not more predictive than tasks based on the words that are not subsequently learnt. The results of this experiment confirm the findings of Experiment 4 which had remained inconclusive because of methodological problems.

The findings of the present experiment also provide support for the results of Experiment 4 by showing that children's ability to learn to read words, at this stage of reading development, is influenced by the regularity of the words they are learning. A strong regularity effect was found across subjects and items in Experiment 5.

## 4.5 General Discussion

The results of Experiments 4 and 5 provide good evidence that children at the very early stages of reading development are influenced by the phonological quality of the words they learn to read. It was shown that children found it easier to learn highly regular words than irregular words. This was not found to be the case in Experiment 2 and 2(b) in which no difference was seen between the learning of regular and irregular words. It is argued that the reason for these different findings is that the irregularity of the words in Experiment 2 was predominantly due to irregular vowels in the words to be learnt whereas in the experiments presented in this chapter it is predominantly the consonants which are irregular. It is suggested that, at this stage of reading development, irregular consonants influence children's ability to learn to read words more than irregular vowels.

Previous research has demonstrated that children's reading errors represent consonants much more consistently than vowels (Stuart & Coltheart, 1988), suggesting that children might use consonants, particularly boundary consonants, in learning to read words in the initial stages of reading development. Similarly, considered in terms of models of reading development such as that proposed by Ehri (1992) children use partial phonological information in words to form connections between print and its spoken form, given their relative consistency, consonants are more likely to be used in forming these partial connections than vowels. It is argued in this chapter that the regularity effects observed in Experiments 4 and 5 are due to the fact the irregular consonants in the words inhibit the formation of connections and hence learning is impaired.

The results of Experiments 4 and 5 do not suggest that tasks based on words to be subsequently learnt are better predictors of word learning than tasks based on words other than those the children are taught to read. Overall word learning is predicted by letter knowledge and by phonemic awareness, as was suggested in the earlier experiments. However, these tasks were predictive whether or not they were based on the words to be learnt or not.

## 4.6 Summary and Conclusions

This chapter has reported two experiments examining the influence of regularity of children's ability to learn to read words and examining the extent to which performance in a range of phonological and semantic tasks predicts the ability to learn to read the words. Unlike in earlier experiments, regularity was found to have a strong influence on word learning. It was argued that this was due to the consonant irregularities in the items used in Experiments 4 and 5 which were not present in the items used in Experiments 2 and 2(b). it was argued that consonants may be particularly important in this very early stage of reading development, in allowing the formation of partial connections between print and its spoken form. As in previous experiments phonemic awareness tasks were shown to be particularly strong predictors of the ability to learn to read the words in the experiment. However, this was found to be the case whether or not these tasks were based on the words to be subsequently learnt or not.

The findings of the experiments presented in this chapter suggest that the ability to access and use phonological information in early word learning is not just confined to purely experimental tasks, as in Experiment 1, but is also found when children attempt to learn 'real words'. These findings contradict traditional stage models of reading development which assert that children at this stage of development are not able to process phonological information and instead rely primarily on salient visual characteristics in order to learn to read words (Frith, 1985). These findings suggest that children do not have to await an alphabetic stage before the phonological quality of the word, and the phonological skills of the child, become important determinants of learning to read words.

# Chapter Five

# Investigating the Interaction between Phonological and Semantic Factors in Early Reading Development

## 5.1 Overview

Previous chapters have presented a series of experiments suggesting that both phonological and semantic factors play an important role in very early reading development. Experiments 1, 4 and 5 showed that even children at the very early stages of reading development are sensitive to the phonological information in words and are able to use this information to form connections between the printed word and its pronunciation. Furthermore, the extent to which children knew the meanings of the words they were learning was shown to influence the ease with which these connections were made. Experiments 2 and 3 showed that children are also influenced by the semantic quality of words early in their reading development. Children find it much easier to learn to read words which are high in imageability than words which were low in imageability. This chapter presents an experiment which investigates the possible interaction between the influence of phonology and semantics in early reading development. An experiment is presented in which children are taught three letters cues, as in Experiment 1. These cues differed both in their phonetic similarity to the target word and in their imageability.

## 5.2 Introduction

Both the phonological and semantic qualities of words have been shown to influence the ease with which beginning readers learn to read them. This finding is contrary to what would be predicted by proponents of traditional stage models. These models emphasise the importance of a word's visual characteristics to younger readers, arguing that children need first to develop alphabetic decoding skills before they are influenced by either the phonological or semantic characteristics of a word (Frith, 1985). What is unclear from the previous studies is whether these phonological and semantic influences are independent influences or whether they might interact during learning or recognition.

As discussed in Chapter 1, Plaut et al. (1996) suggested that the relationship between phonology and semantics might best be considered as a 'division of labour'. They found that as the model learnt a redistribution of labour between the phonological and semantic pathway occurred. As the contribution of the semantic pathway was increased, the phonological pathway became increasingly specialised for pronouncing consistent spelling sound correspondences while the semantic pathway processed exception words. The interaction between the two variables is therefore characterised as a 'division of labour' between a phonological process that deals with mappings between orthographic and phonological representations and an interacting semantic process that deals with mappings between orthographic, semantic, and phonological representations.

Strain et al.(1995) provided some support for this idea by showing that adults only showed imageability effects in their recognition of low-frequency exception words. While there is support for a division of labour in recognition studies with older children and adults it is not clear whether the same process would be seen with much younger children and with word learning rather than word recognition. This chapter presents an experiment in which this possible interaction is examined in the context of young children's word learning.

## 5.3 Experiment 6

### 5.3.1 Introduction

This experiment was designed to investigate the role of phonological and semantic factors in children's ability to learn to read words. One aim was to replicate the finding of the previous experiments that children in the very early stages of reading development are influenced by both the phonological and semantic quality of the words they learn to read. A second aim was to see whether these factors interact or operate independently in early reading development.

The design of the experiment was similar to that used in Experiments 1 and 2. Children were taught to associate three letter cues with spoken target words over a number of days. These words differed both in their phonetic similarity to the target word and in their imageability. Four types of cue were created; high-imageability phonetic, high-imageability control, low-imageability phonetic and low-imageability control cues. It was hypothesised that children would be influenced by both the degree of phonetic similarity and by the imageability of the words they were learning, it was predicted that they would learn the high-imageability cues more easily than the low-imageability cues and the phonetic cues more easily than the control cues. If the phonetic quality and the imageability of the words interact to influence the ease with which the words are learnt, it would be expected that when the use of phonology is most difficult the role of semantics would be greatest, as suggested by Plaut et al. Hence it would be predicted that the strongest imageability effect should be seen with the control cues and that the low-imageability control cues would be particularly difficult for the children to learn.

## 5.3.2 Method

### 5.3.2.1 Participants

Twenty children, 8 boys and 12 girls from a school in York took part in the experiment. Six of the children were from a reception class and 14 were from a Year One class. The mean age of the children in the study was 5 years 3 months (range from 4 years 4 months to 5 years 10 months).

### 5.3.2.1 Design and Materials

The design of Experiment 6 was similar to that of Experiment 1. All the children were taught to associate 3 letter cues with target words. As in Experiment 1, these cues differed in the extent of their phonetic similarity to the target word. The target words differed in their imageability. Four types of cue were created; high-imageability phonetic, high-imageability control, low-imageability phonetic and low-imageability control cues. The children were also given a series of language tasks in order to determine the extent to which these skills contributed to their learning. These tasks are the same as those used in previous experiments and are described fully in Chapters 2 and 3.

#### 5.3.2.1.1 Reading measures

(i) **BAS Single Word Reading** This was the same single word reading test that was used in Experiments 1-5. It is described fully in Chapter 2.

(ii) **Nonword Reading** This was measured using the Graded Nonword Reading Test (Snowling, Stothard, McClean, 1996) described in Chapter 2. The maximum possible score on this test is 24.

(ii) **Letter Knowledge** As in previous studies, this was measured by showing the children printed letters in a random order and asking them to give the name or sound of the letter.

### 5.3.2.1.2 Phonological Awareness Measures

Two phonological awareness measures were taken from a battery of tests devised by Muter, Hulme, & Snowling (1997) and described in detail in Chapter 2.

(i) **Rhyme Detection Test** In this test children are required to indicate which of three words rhymes with a target word. All the items are accompanied by pictures. The total possible score is 10.

(ii) **Phoneme Deletion Test** In this task the child is asked to remove the initial or final phoneme from a single syllable word. The correct response is also a real word. All items are accompanied by pictures. The total possible score is 16.

### 5.3.2.1.3 Semantic Measures

(i) **Vocabulary Test** As in Experiment 2 the vocabulary subtest from the Wechsler Pre-school and Primary Scale of Intelligence - Revised (WPPSI-R) was used. This test includes 3 picture items in which the child is required to offer a definition of the target word. The items are graded in difficulty. The picture items are scored 1 (correct) or 0 (incorrect). The verbal items are scored 0, 1, or 2 according to the response given in the manual in which examples of responses are listed and scored. Testing is discontinued if the child makes 5 consecutive errors. The maximum possible score is 47.

(ii) **Semantic Production** A semantic production task was given. In this the child was given 30 seconds to generate as many words in a given category as possible. There is one demonstration category: colours, and three test categories: animals, food and clothes. Each suitable word scores 1 point.

### 5.3.2.1.4 The Experimental Task

In addition to these general language tasks, the subjects took part in a word learning task over three consecutive days. The child's task was to learn to associate three letter cues with spoken words. Twenty-four target-cue pairings were learnt in three blocks of eight spread over 3 days of testing.

The target words were all bisyllabic words with a CVCVC or CVCV phonemic structure. Half of the target words in the experiment were high-imageability words and half were low-imageability words. Imageability was rated by 15 individuals all of whom were professionals working with children the age of those included in this study. As in Experiments 2 and 3, imageability was defined as the extent to which a word 'can evoke an image in your mind' or 'evoke a clear picture in your mind'. Raters were asked to rate the imageability of a list of words for a young child on a scale of 1-7 where 1 represents extremely low-imageability. The familiarity of words was also rated. Raters were asked to rate words on a scale of 1-5 on the extent to which a young child would have heard a word and would know the meaning of it. Age of acquisition was also rated using a 1-7 scale with each point on the scale representing a possible average age at which a word is acquired by a child. The inter-rater reliability of these ratings was calculated and was found to be high; for familiarity, Alpha= .86, for imageability, Alpha= .98, for age of acquisition, Alpha= .86.

For the purposes of this experiment high-imageability words are defined as words with a mean rating <4.4 and low-imageability is defined as >3.6. Age of acquisition, familiarity, and the number of letters and phonemes in the words were controlled for. The properties of the two groups of words, high- and low-imageability words, are presented in Table 5.1.

**Table 5.1**

Table showing the properties of the two word groups

| Group | Imag. | Famil. | AOA | Letter | Phoneme |
|---|---|---|---|---|---|
| High M | 5.8 | 3.7 | 2.6 | 5.8 | 4.8 |
| SD | 0.7 | 0.7 | 0.7 | 0.4 | 0.7 |
| Low M | 2.6 | 3.7 | 2.7 | 5.8 | 4.6 |
| SD | 0.8 | 0.4 | 0.3 | 0.8 | 0.7 |

In order to confirm that the items in the two conditions differed only in their imageability, separate one-way analysis of variance using each of the variables, and condition as the factors, was undertaken. These analyses confirmed that the two sets of words differed in their imageability ($F(1,23)= 109.5$, $p<.001$) but not in their rated age of acquisition ($F(1,23)= .13$, $p>.05$), familiarity ($F(1,23)= .01$, $p>.05$) or in the number of letters ($F(1,23)= .16$, $p>.05$) and phonemes ($F(1,23)= 1.1$, $p>.05$).

For each of the target words two types of cue were created, phonetic and control. So the experiment included four word groups, high-imageability phonetic, high-imageability control, low-imageability phonetic and low-imageability control. These cues were created in the same way as in Experiment 1. In the phonetic cue condition the middle phoneme was similar to a phoneme in the target word in terms of place and manner of articulation but differed in terms of voicing. Again, five voice/voiceless pairs were used to form the phonetic cues: t/d, p/b, s/z, f/v and k/g. So, for example, the word *hidden* had the phonetic cue 'htn' and the word *robber* had the phonetic cue 'rpr'.

In the control condition the central phoneme in the cue always differed from that in the target word in place of articulation but was always similar in terms of voice and manner of articulation. So, for example 'v' and 'z' differ only in voicing, whereas, 'v' and 'z' differ in place of articulation. The control cues for 'hidden' and 'robber' were 'hgn' and 'rgr'. The words used in this study, and the cues created in each condition are shown in Table 5.2.

**Table 5.2**

High-imageability Words

| | Imageability | Age of Acq. | Familiarity | Letters | Phonemes |
|---|---|---|---|---|---|
| basket | 5.9 | 2.6 | 3.5 | 6 | 6 |
| rabbit | 6.8 | 1.7 | 4.5 | 6 | 5 |
| bacon | 4.9 | 2.8 | 3.5 | 5 | 5 |
| bottle | 6.6 | 1.3 | 4.8 | 6 | 4 |
| wizard | 4.9 | 3.4 | 3.1 | 6 | 5 |
| jacket | 6.2 | 2.4 | 3.8 | 6 | 5 |
| robber | 5.5 | 3 | 3.2 | 6 | 4 |
| button | 6.3 | 2 | 4.7 | 6 | 5 |
| ladder | 6.4 | 2.6 | 4 | 6 | 4 |
| river | 5.7 | 2.9 | 3.7 | 5 | 4 |
| coffee | 4.8 | 3.3 | 3.6 | 6 | 4 |
| ticket | 5.4 | 3.2 | 3.2 | 6 | 5 |

**Table 5.3**

Low-imageability Words

| | Imageability | Age of Acq. | Familiarity | Letters | Phonemes |
|---|---|---|---|---|---|
| noisy | 3.6 | 2.4 | 4.3 | 5 | 4 |
| trouble | 3.4 | 2.3 | 3.9 | 7 | 5 |
| heavy | 3.4 | 3 | 3.7 | 5 | 4 |
| looked | 3 | 2.9 | 3.7 | 6 | 4 |
| listen | 2.9 | 2.3 | 4.5 | 6 | 5 |
| visit | 2.5 | 2.9 | 3.1 | 5 | 5 |
| ready | 2.1 | 2.6 | 3.7 | 5 | 4 |
| because | 1.2 | 2.6 | 3.5 | 7 | 5 |
| hidden | 2.4 | 2.9 | 3.3 | 6 | 5 |
| better | 1.8 | 2.4 | 3.9 | 6 | 4 |
| never | 1.6 | 2.7 | 3.4 | 5 | 4 |
| middle | 3.3 | 3.1 | 3.3 | 6 | 4 |

**Table 5.4**

Cues created from the High and Low-imageability Words

| *High-imageability* | | | *Low-imageability* | | |
|---|---|---|---|---|---|
| Phonetic | Control | | Phonetic | Control | |
| *basket* | bzkt | bfkt | *noisy* | nzi | nfi |
| *rabbit* | rpt | rgt | *trouble* | trpl | trgl |
| *bacon* | bgn | bpn | *heavy* | hfi | hzi |
| *bottle* | bdl | bpl | *looked* | lgd | lpd |
| *wizard* | wsd | wfd | *listen* | lzn | lfn |
| *jacket* | jgt | jpt | *visit* | vzt | vft |
| *robber* | rpr | rgr | *ready* | rti | rki |
| *button* | bdn | bpn | *because* | bgs | bps |
| *ladder* | ltr | lkr | *hidden* | htn | hgn |
| *river* | rfr | rzr | *better* | bdr | bpr |
| *coffee* | kvi | ksi | *never* | nfr | nzr |
| *ticket* | tgt | tpt | *middle* | mtl | mkl |

Two forms of the experiment were constructed so that each target word appeared in each form once, in either the phonetic or control condition. So, if 'wizard' appeared as 'wsd' in one form it would appear as 'wfd' in the other form.

Each form of the experiment contained 24 words, 12 phonetic cue words and 12 control cue words. The cues were then grouped in three blocks of eight with two words in each condition in each block of eight. The child was presented with one block a day for three consecutive days. The order of presentation of each of the three word groups was counterbalanced.

#### 5.3.2.2 Procedure

The general language measures were administered first, over one or two days depending on the concentration span of the child. The testing took place in a small, quiet area outside the classroom.

For the word learning task the child was tested on three consecutive days. The procedure was very similar to that used in Experiment 1. The children were told that they were going to learn some 'made up words' with funny spellings and were told to see if they could remember which word goes with which card. Each cue was presented to the child and the experimenter said the target word twice with the child repeating the word once. On the first presentation the card remained in view for 5s. The cards were then shuffled to produce a different order. The cards were then presented to the child and the child was asked to recall the target word. Refusals and errors were corrected. Testing was discontinued after six trials. The child scored 1 for a correct response and 0 for an incorrect response.

### 5.3.3 Results

#### 5.3.3.1 Results of the Word Learning Task

The results of the word learning are presented first. In this task each cue that the child was required to learn was given a score from 0 to 6 with one point for each correct recall of the associated target word. With six items the maximum possible score for each condition was 36 and the maximum total score was 144. The mean values and standard deviations for each shown in Table 5.5.

**Table 5.5**

Mean Scores (and Std. deviations) in the cue learning task

| | Phonetic | Control |
|---|---|---|
| High imag. | 26.2 (6.02) | 19.2 (6.02) |
| Low imag. | 19.6 (8.51) | 14.7 (8.99) |

(Max possible score in each condition=36)

It can be seen from Table 5.5 that the children learnt more phonetic cues than control cues and more high-imageability words than low-imageability words. There does not appear to be a difference between the phonetic cue effect (the difference between phonetic and control cue learning) in the high and low-imageability conditions. Similarly, there does not appear to be a difference between the imageability effect (the difference between high and low-imageability cue learning) in the phonetic and control conditions.

The data were subjected to a within subjects analysis of variance in which the factors were Cue (phonetic or control) and Imageability (high or low). There was a strong main effect of cue type ($F(1,19)=56.02$, $p<.001$) and a strong main effect of imageability ($F(1,19)=16.39$, $p=.001$). This confirms the hypothesis that both cue type and imageability had an effect on the ease with which cues were learnt. No significant imageability x cue type interaction was found ($F(1,19)=1.54$, $p>.05$). Hence, the effect of cue type did not vary as a function of imageability.

A by-items analysis of variance was conducted in order to confirm generality of effects across items as well as subjects. The mean scores for each of the item groups is presented in Table 5.6.

**Table 5.6**

Mean scores of items in all conditions

| | Phonetic | Control |
|---|---|---|
| High Imag. Items | 4.37 (.92) | 3.18 (1.02) |
| Low Imag. Items | 3.20 (.87) | 2.45 (.73) |

There were two factors in this analysis, Imageability and Cue Type. A main effect of Imageability ($F(1,11)=17.72$, $p<.001$) and a main effect of cue type

($F(1,11)=12.57$, $p<.002$) was found. However, the interaction between imageability and cue type was not significant ($F(1,11)=.71$, $p>.05$). These results confirm the findings of the by-subjects analysis.

#### 5.3.3.2 Examining the relationship between learning and the language measures

It was expected that word learning would be strongly related to performance in the language tasks. The mean scores in each of these tests in given in Table 5.7

**Table 5.7**

Mean Performance on the Phonological and Semantic Tasks

| | Mean | Std.Dev. |
|---|---|---|
| BAS | 17.55 | 21.82 |
| Nonword | 4.55 | 5.67 |
| Phoneme Deletion | 7.20 | 6.07 |
| Letter Knowledge | 22.55 | 3.68 |
| Vocabulary | 20.15 | 8.13 |
| Semantic Production | 23.75 | 6.66 |
| Rhyme Detection | 7.60 | 3.14 |

The relationship between these language measures was examined first. The correlations between the measures were computed, and are shown in Table 5.8. It can be seen that all the measures correlate significantly with the BAS reading score. There are also strong correlations between the vocabulary scores and the other language measures, in particular between vocabulary and phoneme deletion.

**Table 5.8**

Correlations between language measures

| | age | BAS | N/W | letter | phond | rhyme | sem. |
|---|---|---|---|---|---|---|---|
| age | | | | | | | |
| BAS | .49* | | | | | | |
| N/W | .48* | .85** | | | | | |
| letter | .36 | .56* | .58** | | | | |
| phond | .37 | .54* | .70** | .56* | | | |
| rhyme | .25 | .48* | .35 | .33 | .40 | | |
| sem. | .40 | .48* | .56* | .44* | .37 | .55* | |
| vocab | .37 | .61* | .70** | .47* | .71** | .65** | .60** |

*=p<.05, **=p<.001

KEY: N/W= nonword reading, phond= phoneme deletion, sem= semantic production; vocab= vocabulary

Table 5.9 shows the correlations between the learning scores and performance on the language measures. Three measures from the word learning task were used. The total score refers to the total cue learning score regardless of condition. The phonetic cue score is also used as a measure with the control cue score partialled out. By controlling for performance with the control cues the phonetic cue score becomes a measure of the extent to which children learn the phonetic cues more easily than the control cues. Similarly, the high-imageability score is used as a measure with the low-imageability score controlled for. By controlling for the low-imageability cue score the high-imageability score becomes a measure of the extent to which children learn high-imageability words more easily than low-imageability words. This procedure was described fully in Chapter 2. The correlations between these cue learning scores and the language measures are shown in Table 5.9

**Table 5.9**

Correlations between language measures and cue learning scores

| | age | BAS | N/W | letter | phond | rhyme | vocab | sem. |
|---|---|---|---|---|---|---|---|---|
| Phoncue | .41 | .45* | .41 | .15 | .55* | .41 | .77* | .17 |
| Highcue | .29 | .51* | .33 | .47* | .27 | .55* | .40 | .41 |
| Total | .46* | .76** | .78** | .68** | .70** | .53* | .78** | .61* |

*=p<.05, **p<.001

It can be seen there are strong correlations between the total score and most of the language measures, the correlations are particularly strong with nonword reading, phoneme deletion and vocabulary scores. The phonetic cue score correlates with performance in the single word reading, phoneme deletion and vocabulary test, even when performance in the control cue condition is controlled for. This suggests that children's sensitivity to the phonetic information in the cue, as measured by the extent to which they learn the phonetic cues more easily than the control cues, is related to children's reading and vocabulary skills and to their phonemic awareness. The high-imageability score correlates with performance in the single word reading, letter knowledge and rhyme detection tests. This suggests that the extent to which children learnt the high-imageability words more easily than the low-imageability words is predicted by these measures.

To explore the extent to which measures of phonological and semantic skill could account for variance in performance in the cue learning task a series of regression analyses was conducted. In the first analyses the total cue learning score was taken as the dependent variable. In a hierarchical regression, age, BAS single word reading score and the nonword reading score were entered first and accounted for a large amount of the variance (65.4%, $p<.001$). After these factors had been controlled for, the phonological and semantic measures were entered. Only the vocabulary score accounted for any significant variance after age, BAS, nonword reading and the semantic production score had been entered, accounting for 7.3% ($p<.05$). However, when phoneme deletion is also added, vocabulary is no longer significant

**Table 5.10**

Summary of hierarchical regression with total score as the dependent variable

| STEP. | VARIABLE | % VARIANCE |
|---|---|---|
| 1. | Age, BAS, N/W | 65.4** |
| 2. | Semantic Production | 4.6 |
| 3. | Vocabulary | 7.3* |
| 4. | Rhyme | 0 |
| 5. | Letter | 2.9 |
| 6. | Phoneme Deletion | 0.2 |
| 2. | Phoneme Deletion | 4.5 |
| 3. | Semantic Production | 5 |
| 4. | Vocabulary | 3.3 |
| 5. | Rhyme | 0 |
| 6. | Letter | 2.1 |
| 2. | Letter | 4.9 |
| 3. | Phoneme Deletion | 2.4 |
| 4. | Semantic Production | 3.9 |
| 5. | Vocabulary | 4.0 |
| 6. | Rhyme | 0 |
| 2. | Vocabulary | 10.8* |
| 3. | Rhyme | 0.1 |
| 4. | Letter | 3.3 |
| 5. | Phoneme Deletion | 0 |
| 6. | Semantic production | 0.7 |
| 2. | Rhyme | 5.8 |
| 3. | Letter | 3.8 |
| 4. | Phoneme Deletion | 0.9 |
| 5. | Semantic Production | 1.5 |
| 6. | Vocabulary | 3.2 |

**=p<.001, *=p<.05

A second analysis was done using total score as the dependent variable but omitting BAS and nonword reading from the analysis. Again, none of the variables accounted for any unique variance in total learning score, although vocabulary scores accounted for significant variance and letter knowledge accounted for marginally significant variance, on the penultimate step. The results of this analysis are presented in Table 5.11.

**Table 5.11**

Summary of hierarchical regression with total score as the dependent variable

| STEP | VARIABLE | % VARIANCE |
|---|---|---|
| 1. | Age | 25.5* |
| 2. | Letter | 26* |
| 3. | Phoneme Deletion | 10.4* |
| 4. | Semantic Production | 7.4 |
| 5. | Vocabulary | 7.2* |
| 6. | Rhyme | 0 |
| 2. | Phoneme Deletion | 28.3* |
| 3. | Semantic Production | 11.3* |
| 4. | Vocabulary | 6.9 (p<.07) |
| 5. | Rhyme | 0 |
| 6. | Letter | 4.5 |
| 2. | Semantic Production | 21.5* |
| 3. | Vocabulary | 22.6* |
| 4. | Rhyme | 0 |
| 5. | Letter | 6.5 (p<.07) |
| 6. | Phoneme Deletion | 0.4 |
| 2. | Rhyme | 19.2* |
| 3. | Letter | 16.7* |
| 4. | Phoneme Deletion | 6.3 |
| 5. | Semantic Production | 3.5 |
| 6. | Vocabulary | 5.6 |
| 2. | Vocabulary | 42.1** |
| 3. | Rhyme | 0.1 |
| 4. | Letter | 7.7* |
| 5. | Phoneme Deletion | 0.2 |
| 6. | Semantic Production | 1.1 |

**=p<.001, *=p<.05

Hierarchical multiple regression was also used to examine the degree to which the language measures were able to predict children's ability to learn the phonetic cues more easily than the control cues, i.e. the extent to which children are sensitive to the phonetic information in the cue. In the regression the phonetic cue score was the dependent variable. By always entering the control cue score on the first step, along with age and BAS score, it was possible to examine the extent to which phonetic cues were learnt more easily than control cues, and which variables, if any, are able to predict the phonetic cue effect. The results of these analyses are shown in Table 5.12.

**Table 5.12**

Summary of hierarchical regression with phonetic cue score as the dependent variable

| STEP | VARIABLE | %VARIANCE |
|---|---|---|
| 1. | Age, BAS, Control Cue | 80 |
| 2. | Rhyme | 2.7 |
| 3. | Semantic Production | 0 |
| 4. | Letter Knowledge | 0 |
| 5. | Vocabulary | 9.4* |
| 6. | Phoneme Deletion | 0.2 |
| 2. | Semantic Production | 0.2 |
| 3. | Letter Knowledge | 0 |
| 4. | Vocabulary | 11.9** |
| 5. | Phoneme Deletion | 0.2 |
| 6. | Rhyme | 0 |
| 2. | Letter Knowledge | 0 |
| 3. | Vocabulary | 11.7** |
| 4. | Phoneme Deletion | 0.4 |
| 5. | Rhyme | 0 |
| 6. | Semantic Production | 0.3 |
| 2. | Vocabulary | 11.7** |
| 3. | Phoneme Deletion | 0.4 |
| 4. | Rhyme | 0 |
| 5. | Semantic Production | 0.3 |
| 6. | Letter Knowledge | 0 |
| 2. | Phoneme Deletion | 5.1* |
| 3. | Rhyme | 1.8 |
| 4. | Semantic Production | 0 |
| 5. | Letter Knowledge | 0 |
| 6. | Vocabulary | 5.3* |

Age, BAS score and the control cue score accounted for a very large percentage of the variance in phonetic cue learning (80%, p<.001), it is, therefore, unsurprising that few variables accounted for additional variance. Two variables accounted for significant variance when added after age, BAS and the control cue score; phoneme deletion (5.1%, p<.05) and the vocabulary score. Performance in the vocabulary test accounted for unique significant variance when added on the final step (5.3%, p<.05).

These results differ from those in Experiment 1 in which phoneme deletion was the only variable to account for unique significant variance. Here phoneme deletion is not significant on the final step. However, it is important to note the small sample size in this experiment compared with the large number of participants in Experiment 1.

#### 5.3.3.2 Further investigating the interaction between factors

Another way of considering the possible interaction between phonology and semantics is to consider differences between good and poor readers. The 'division of labour' between phonology and semantic factors may result in those with poor phonological skills relying more on the semantic representations of the words they are learning than those with good phonological skills. In order to investigate this possibility the children taking part in this experiment were divided into two groups according to their reading ability. Although the number of children in each group was now small, this crude arrangement provided a way of investigating a possible trend towards phonology and semantics interacting as a function of reading level.

The participants were divided into two groups according to their reading ability. The ten best readers formed one group. The mean number of words read in the single word reading test for this group was 31.6 (23.4). The remaining ten children read a mean of 3.5 (4.22) words on the test and hence formed the poor reader group. The good reader group had a mean age of 5 years, 6 months and the poor reader group had a mean age of 5 years, 2 months. The performance of the two groups of children on the phonological and semantic tests is shown in Table 5.13.

**Table 5.13**

Performance of the Good and Poor Readers on the Phonological and Semantic Tasks

| | Phond. | Rhyme | Sem | N/Word | Letter | Vocab. |
|---|---|---|---|---|---|---|
| Good | 9.1 (6.2) | 9.2 (1.9) | 27.4 (5.2) | 7.5 (6.2) | 24.3 (1.7) | 23.6 (7.8) |
| Poor | 5.3 (5.6) | 6 (3.4) | 20.1 (6.1) | 1.6 (3.1) | 20.8 (4.3) | 16.7 (7.3) |

The performance of the good and poor readers in the cue learning task is shown in Table 5.14

**Table 5.14**

Performance of good and poor readers in the cue learning task

| | | Phonetic | Control |
|---|---|---|---|
| Good | High | 30.3 (3.83) | 21.8 (4.64) |
| | Low | 24.1 (8.41) | 20.3 (7.51) |
| Poor | High | 22.1 (4.95) | 16.6 (6.33) |
| | Low | 15 (6.02) | 9.10 (6.67) |

It can be seen from Table 5.14 that both good and poor readers found the phonetic cues easier to learn than the control cues. The means suggest that the poor readers show a stronger imageability effect, that is the poor readers appear to be more influenced by imageability in their learning. The good readers do not appear to show a difference in their ability to learn high and low-imageability cues in the control condition.

The data for these two groups was subjected to analysis of variance with Imageability and Cue Type as the factors. Two way analysis of variance revealed a significant effect of imageability ($F(1,18)= 16.92$), $p<.001$), and a significant effect of cue type ($F(1,18)=53.3$, $p<.001$). However the group by imageability ($F(1,18)=1.62$, $p>.05$) and the group by cue ($F(1,18)=.08$, $p>.05$) interactions were not significant, suggesting that the groups are not differentially affected by imageability or by the phonological quality of the cue. Although this two way analysis does not show a significant difference between the imageability effects shown by the good and poor reader groups the means and the separate analyses certainly suggest a trend in this direction.

Separate analysis of variance revealed a significant main effect of imageability ($F(1,9)=24.8$, $p=.001$) and a significant main effect of cue type ($F(1,9)=30.75$), $p<.001$) for the poor readers, but no interaction between these two factors ($F(1,9)=.02$, $p>.05$). However, the good readers showed a slightly different pattern. The good readers did not show an imageability effect ($F(1,9)=2.85$, $p>.05$) but showed a strong cue effect ($F(1,9)=23.9$, $p=.001$) and a significant cue by imageability interaction ($F(1,9)=5.07$, $p=.05$). Examination of the means for this group suggest that with the control words they do not show an imageability effect. This is contrary to what might be predicted by models suggesting that when phonological translation is most difficult, semantic information will have its biggest influence.

Clearly the results of this sub-group analysis need to be interpreted cautiously given the small sample size. However, they do suggest that further consideration of the differential use of phonological and semantic information by good and poor beginning readers is needed.

### 5.3.4 Discussion

The results of Experiment 6 confirm the findings of previous experiments in showing that beginning readers are influenced by both the phonological and semantic quality of words they learn to read. Experiment 6 showed that children found it easier to learn to associate three letter cues with spoken words when the cues were phonetically similar to the spoken target words than when cues were less phonetically similar. Furthermore, words high in imageability were learnt more easily than low-imageability words. As has been discussed in previous chapters, these results are contrary to what would be predicted by many theories of reading development. Together these experiments provide good evidence that children are able to access and use phonology from the very early stages of reading development. These findings provide support for those who view learning to read as a process of setting up connections, or partial connections, between some of the letters in a word and the spoken pronunciation of the word (Ehri, 1992; Rack et al. 1994). Furthermore, the fact that children at this very early stage of reading development are shown to be sensitive to such small units of phonology and are sensitive to phonetic information at a featural level provides support for the notion of distributed featurally based representations of phonology proposed in connectionist models of words recognition (Seidenberg & McClelland, 1989). The finding that imageability also influences the ease with which children in the beginning stages of reading are able to learn to read words, suggests a second form of direct mapping, working in parallel with the processes involved in mapping orthography onto phonology.

Experiment 6 also attempted to examine the relative role of semantic and phonological information in the acquisition of word reading skills. One possible way in which phonology and semantics might interact is that when the use of one type of information is limited, the other has a greater influence. Plaut et al. (1996) proposed a division of labour between the phonological and semantic pathway in reading. They argue that the influence of semantics is particularly important in words for which orthographic to phonological translation is difficult, i.e. exception words, and in particular in low-frequency exception words. Four types of abbreviated words in this experiment were used to investigate the way in which phonological and semantic information might interact to influence word learning. It was reasoned that if these two variables interacted in the way described above then the learning of cues which were less phonetically similar to the target spoken word would be more influenced by the semantic quality of the word; that is, the learning of control cues would show a stronger imageability effect than the learning of phonetic cues.

The results of Experiment 6 did not suggest that such an interaction occurs in this very early stage of reading development. While both imageability and the degree of phonetic similarity of the cue influenced the ease with which words were learnt, these appear to be separate influences. A larger imageability effect was not found in the learning of the control cues as would be predicted by the division of labour hypothesis, indeed the reverse was found with a slightly larger imageability effect for the phonetic cues. There are a number of reasons why the predicted interaction may not have been observed. Firstly, the Plaut et al. (1996) model and the findings of Strain et al. (1995) discussed in the introduction are based on word recognition rather than on word learning. It may be that slightly different processes are involved in recognition and learning. The Strain et al. study examines the state of the reading system in adulthood; it does not necessarily follow from their findings that such an interaction would be found in the process of establishing connections between print and its spoken form. Furthermore, it is important to note that the size of the effects found in the Strain et al. study were small and were only found in one experiment. Further research is required in order to establish the robustness of the interaction they reported, and more generally the exact nature of the relationship between semantic and phonological processing in adult word recognition.

A second reason why an interaction may not have occurred in this experiment therefore, might be developmental. According to Plaut et al. establishing connections in the phonological pathway is primary in the learning phase, they argue that the semantic pathway makes a substantial contribution to reading "only once the phonological pathway has developed to some degree". Therefore it is possible that an interaction may be seen at a later stage of development but not at this very early stage of reading development. However, it should be noted that the children in this experiment, and those in the previous chapters were shown to be using the semantic pathway in establishing connections between printed words and their pronunciations from a very early stage. It may be possible that semantics makes a contribution to word learning earlier than previously thought. Nevertheless, it may still be the case that an interaction between the contribution of phonology and semantics may only be seen at a later stage. It is possible that neither pathway is sufficiently developed for an interaction to be observed at this stage. As the phonological pathway becomes more competent, tests of word learning and recognition may be more likely to be sensitive to an interaction with semantics. It is clear that the children in this experiment are accessing and using phonological information in learning the cues because they learn cues with more phonetic information more efficiently than cues with less phonetic information. However, it may be that this difference in cue learning is not sufficient to allow an interaction to be observed.

It is reasonable to suggest, therefore, that phonological and semantic information make independent contributions to reading in the very early stages of reading development. It could be that partial activations across both phonological and the semantic units are important in early word learning. Children in this early stage of reading development have not developed competent phonological or semantic pathways and it is possible that partial information is used from each of these pathways to aid recognition. Put simply, children at this stage may use any information or partial cue they can in their word learning because they have not developed a systematic approach to reading. This information may be phonological, visual, contextual, or semantic in nature.

Another way of conceptualising an interaction between phonology and semantics is in terms of a deficit in processing in one pathway. The 'division of labour' hypothesis would predict that such a deficit in one pathway may lead to an over dependence on the contribution from the other pathway. In terms of very early reading development, this might predict the use of both pathways in the manner observed in this experiment because in children this young processing in both pathways is weak. Indeed, it may be possible to predict that as children get older and their phonological processing becomes more efficient, they will be less likely to be influenced by semantic factors in their word recognition. Although there is evidence that the lexical processing of skilled readers is still influenced by semantic variables such as imageability, these effects tend only to be for certain types of words, i.e. low-frequency, exception words (Strain et al., 1995).

A further prediction would be that subjects with poor phonological processing would be more influenced by the semantic quality of words or that subjects with impaired semantic processing would have particular difficulty with words which may rely more on the semantic pathway, i.e. low frequency exception words. There is some evidence from Experiment 6 that phonology and semantics may interact in this way even from an early age. Although the results from the comparison of the good and poor readers in the experiment are somewhat mixed, it is clear that there is a trend towards the poor readers, with less efficient phonological processing skills, being more influenced by imageability than the children with better phonological skills. Given the limitations and problems with this study this can only be a tentative suggestion but it would seem worthy of further investigation.

## 5.4 Summary and Conclusion

Experiment 6 examined the influence of phonological and semantic information on the ability to learn to read words in the very early stages of reading development. Children were found to be influenced by both the phonological and the semantic qualities of the words they were learning, suggesting that both these processes are important in this early stage of reading development. Phonology and semantics were seen to make independent contributions to early word learning.

However, a comparison of good and poor readers did suggest that an interaction between these two factors might manifest itself in children with particularly poor phonological skills being more influenced by the semantic quality of the words they are learning to read. There are problems with this comparison, however, particularly the small sample size. In the next chapter an experiment is presented which compares the learning of good and poor beginnings readers more systematically.

# Chapter Six

# The Influence of Phonological and Semantic Factors on Good and Poor Beginning Readers

## 6.1 Overview

Experiments 1 and 2 showed that early word learning is influenced by the semantic variable, imageability. Children in the early stages of reading development appear to find it easier to learn to read words which are high in imageability than to learn words which are low in imageability. Experiment 3 demonstrated that this 'imageability effect' remains when all the words to be learnt are from the same grammatical category, thus confirming the effect is not merely a reflection of a grammatical bias in learning. Experiments 1, 2, 4 and 6 all showed that phonological factors also influence young children's ability to learn to read words. Firstly, children's overall rate of learning was shown to be closely related to independent measures of phonological skill. Secondly, Experiments 1 and 2 demonstrated that even in the very early stages of reading development children are sensitive to phonetic information in words and are able to learn three letter abbreviated words more easily when they are phonetically similar to the target word than when they are phonetically dissimilar (referred to as the phonetic cue effect in these earlier studies). Experiments 2 and 6 suggested that these phonological and semantic factors influence word learning independently as no interaction between the two was found. This chapter will investigate the relationship between these two factors further by considering their influence on good and poor readers.

## 6.2 Experiment Seven

### 6.2.1 Introduction

Experiment 7 was designed with the aim of further investigating the relationship between phonological and semantic factors in learning to read, by considering their possible differential influence on good and poor beginning readers. Experiment 6 examined the learning of abbreviated words (cues) that differed in their phonetic content and in their imageability. In this study learning was found to be influenced by both factors; the phonetic content of the cue (phonetic cues were learnt more easily than control cues) and its imageability (high-imageability cues were learnt more easily than low-imageability cues). These two factors made independent contributions to learning and did not interact. However, it was the case that when the participants were divided into two groups according to their reading ability, the pattern was slightly different. Now the poor readers showed a strong imageability effect while the good readers did not. However, there were problems with interpreting these findings, in particular, the number of children in each reader group was very small (N=10). Nevertheless, it was considered worthwhile investigating this issue further, by increasing the number of participants and by using strict criteria by which to select the groups of good and poor readers.

There are some theoretical grounds for believing that good and poor readers may be influenced differently by these two factors in their reading. Firstly, there is some evidence that good and poor readers are differentially affected by context effects in word recognition. In terms of models of reading this may be considered in terms of compensation, that is, strengths in one domain may compensate for weaknesses in another. As discussed in Section 1.7 of Chapter 1 Stanovich (1980) and Perfetti & Roth (1981) suggest that difficulties with phonological skills may be compensated for by good semantic skills. A prediction from this model is that individuals with an impaired phonological system should show a greater reliance on semantics than readers with intact phonological systems. The studies reviewed in Section 1.7 provide some support for this hypothesis. Poor readers have been shown to display greater context facilitation effects than good readers (Pring & Snowling, 1986; Nation & Snowling, 1998).

This notion of compensation can be related to a connectionist model of word recognition proposed by Plaut, McClelland, Seidenberg and Patterson (1996) described in Section 1.7. In this model the interaction between phonology and semantics is described as a "division of labour" in that as learning proceeds a redistribution of labour between the phonological and semantic pathway occurs and the phonological pathway becomes increasingly specialised in pronouncing words with consistent spelling sound correspondences. The two pathways interact with each other so that when one pathway is impaired the other becomes all the more important. This model is relevant not only to understanding the processes involved in text reading, but also to single word reading. The findings of Strain, Patterson & Seidenberg (1995) provide some support for this model. Strain et al. (1995) argued that semantic factors would be most likely to come into play when orthographic to phonological translation is most difficult, for example, in low-frequency exception words. They found that even skilled adult readers were influenced by imageability in their recognition of these words.

However, Experiment 6 suggested that phonological and semantic factors make independent contributions to children's early word learning. Children's ability to learn to associate three letter cues with spoken target words was shown to be influenced by both the imageability of the word and the phonetic quality of the cue, no interaction was found between these factors. In Chapter 5 it was suggested that while an interaction may become apparent with development, at this very early stage of learning to read, children appear to use both semantics and phonology to aid word recognition in a rather unsystematic way. Although semantic and phonological factors did not interact in word learning, a trend towards an interaction was seen when the best and worst readers were considered separately: there was a trend towards the poor readers showing a stronger imageability effect than the good readers. This finding suggests that those with good phonological skills are less influenced by the semantic quality of the words they are learning as they are better placed to access and use the phonological representation of the words. However, the results of Experiment 6 are somewhat inconclusive, possibly due to the post hoc way in which the groups of good and poor readers were created. Experiment 7 aimed to consider the possible differential use of semantic and phonological cues in words learning in a more systematic way.

There is some evidence that when the phonological system is impaired, as in poor readers, the semantic system may be depended on to a greater extent. Byrne & Shea (1979) and, using the same paradigm, Waterman & Lewandowski (1993) examined the phonological and semantic processing of good and poor readers in a short-term memory experiment. The children were required to say which, from a possible four words, was the word they had previously heard. The possible words were from one of four categories; a word which rhymed with the target word, a word which contained the same number of phonemes as the target word, a semantically similar word and a semantically dissimilar word. It was found that with nonwords both groups of reader confused the target word with the rhyme control more than with the non-rhyme control in the nonword condition, suggesting the poor readers were as susceptible to a phonemic confusability effect as the good readers. It was argued that when the poor readers were unable to rely on the semantic qualities of a word, e.g. in the nonword condition they depend on the phonology of a word in a similar way as the good readers. However, when the items in the experiment were words the poor readers showed less of a phonemic confusability effect, suggesting they are less sensitive to the phonology of the word. Byrne & Shea suggested that when a different means of coding is available, i.e., a semantic coding system, the poor readers may be more likely to rely on this than the good readers.

A number of studies suggest that imageability might influence word recognition in poor readers more than in good readers (Jorm, 1977; Coltheart, Laxon & Keating, 1988). The poor readers in these studies were found to show a stronger imageability effect than the good readers in word recognition and recall. However, the differential effect of imageability on word learning, in particular by very young children at the early stages of reading development has not been examined. Although it has commonly been assumed that semantic influences in early word recognition must be limited to a later stage of reading development and that phonological factors will be primary in early word learning, experiments 2, 3 and 6 provided evidence that beginning readers are influenced by semantic factors, such as imageability.

The aim of the present experiment is to consider the influence of semantic and phonological factors on early word learning for good and poor readers. As suggested above there are theoretical grounds for predicting that good beginning readers might perform differently from poor beginning readers. It would seem from the above evidence that poor beginning readers may be more influenced by the semantic factor, imageability, in learning to read a set of novel items. This may be because they rely more on this pathway due to the limitations of their phonological pathway. Similarly, the good reader group may rely more on the phonological representation of the word and should, therefore, be less dependent on its semantic representation.

It is also predicted that good beginning readers will learn more cues, at a faster rate, than poor beginning readers. Furthermore, it was expected that, as in previous studies, the overall learning rate would be predicted by independent measures of phonological skill. Ehri & Saltmarsh (1995) compared the performance of advanced and novice first graders and older disabled children on a word learning task. The children were taught simplified phonetic spellings of 16 words for several trials. Three days later the children were asked to read the original words as well as some altered spellings in which single letters were added, deleted or replaced by phonetically equivalent or non-equivalent words. They also found that the disabled and novice readers took considerably more trials to learn to read the original items than the advanced beginning readers. All groups read the original spellings faster than the altered spellings. The advanced readers were sensitive to almost all the types of alteration made, suggesting that they had established near complete representations for the words. The novice group were not sensitive to as many types of letter alteration and the disabled reader group were only sensitive to the most salient letter changes, suggesting that they only retained partial representations of the words in lexical memory. From the above studies, it would seem that there are good grounds for expecting that both the rate of learning and the type of information learnt may vary as a function of reading skill.

The Ehri & Saltmarsh (1995) study suggests that the degree of sensitivity to phonetic information present in a word, and the extent to which children use this information, varies as a function of reading skill. Similarly, if the phonetic cue effect seen in experiments 1, 3 and 5 is taken as a measure of the degree to which children are sensitive to the phonology of a word, then it would be predicted that good readers would be more sensitive to the phonemic overlap between the cue and the target word, and hence show a greater phonetic cue effect than the poor readers.

In the present study, two groups of readers in their second year of reading instruction were taught to associate 20 cues with spoken target words differing in their imageability over two consecutive days. It was predicted that the poor readers would rely more on semantic influences in their learning, and show a greater imageability effect than the good readers. Conversely, the good readers would be more able to rely on the phonological attributes of the cues and it is, therefore, predicted that they would show a weaker imageability effect but a stronger phonetic cue effect than the poor reader group.

## 6.2.2 Method

### 6.2.2.1 Participants

Thirty six children aged between 5 and 6 years old took part in study seven. All of these children were in Year One, that is, they were in their second year of primary education. The children came from a number of schools in Cumbria. These children had already taken part in another study, a year prior to this study, and so some data was already available for them. These data were used to create two groups of children for the present study, 'good beginning readers' and 'poor beginning readers'. The children had been tested in the previous year on a variety of phonological awareness measures, and on reading and IQ tests. These tests are described fully in section 6.2.2.2.

The poor reader group was made up of 18 children who had been able to read 5 or less words on the British Ability Scales single word reading test when tested while in the reception class, and who were still unable to read. There were seven boys and eleven girls in this group. The good reader group comprised 18 children who were reading age appropriately, or who were reading in advance of their chronological age. There were ten boys and eight girls in this group. The groups differed on measures of reading ability, letter knowledge, nonword reading and phonological awareness but were matched on age and IQ, as measured by a matrices and vocabulary task described in section 6.2.2.2.

The mean chronological age for the poor reader group was 5 years 5 months (range from 5 years to 5 years 11 months). The mean chronological age for the good readers group was 5 years 7 months (range from 5 years to 6 years). Table 6.1 shows the performance of the two groups on a test of single word reading (BAS), a test of early word recognition (EWR), letter knowledge, nonword reading (NW), phoneme deletion (ph), and rhyme production and deletion (Rhyp/d). These tasks are described in detail in section 6.2.2.2.

**Table 6.1**

The language skills of the good and poor reader groups

| | age.yrs | IQ | BAS | EWR | letter | Rhyp | Rhyd | phb. | phe. | NW |
|---|---|---|---|---|---|---|---|---|---|---|
| Good | 5.7 | 108 | 18.7 | 29.4 | 24.3 | 10.6 | 13.7 | 10.7 | 8.6 | 3.9 |
| Sd | .36 | 9.5 | 8.2 | 8.4 | 1.2 | 5.7 | 6.2 | 5.6 | 7.5 | 4.1 |
| Poor | 5.5 | 108 | 1.06 | 4.9 | 17.1 | 5.8 | 8.6 | .44 | .06 | .06 |
| Sd | .31 | 7.5 | 1.95 | 4.3 | 8.1 | 5.2 | 5.4 | 1.4 | .24 | .24 |

key: EWR -early word recognition test; rhyp = rhyme production; rhyd = rhyme detection; phb = initial phoneme deletion; phe = end phoneme deletion; NW = nonword reading

It can be seen from the above table that the two groups differ in their single word reading, letter knowledge and phonological skills but do not differ in their age or general intelligence.

### 6.2.2.2 Design and Materials

All the children had been given a battery of measures, as part of another study, a year earlier (time1). These measures are described below. A number of tasks were also repeated at time 2, the time of the present study.

(i). **Single Word Reading** The British Ability Scales (Elliot, Smith & McCulloch, 1996) test of single word reading was administered. This is the same single word reading test that has been used in studies 1-6 and is described fully in Chapter 2. However, the test used here is a newer addition of the British Ability

Scales and a small number of words in the reading test have changed. Testing was discontinued after 10 consecutive errors.

**(ii). Early Word Recognition Test** This test was devised by Hatcher, Hulme & Ellis (1994) to measure early sight vocabulary. Seven sets of six words each, taken from a selection of frequently used reading schemes, is presented to the child. There is no discontinuation rule. The child's responses are scored as correct or incorrect. The maximum possible score is 42.

**(ii). Letter Knowledge** Letter knowledge was assessed by presenting the children with lower case letters printed on individual cards. They were presented in random order and the children were asked to provide either the name or the sound of the letter.

**(iv). Nonword Reading** Nonword reading was measured using the Graded Nonword Reading Test (Snowling, Stothard & McLean, 1994). The test comprises 20 nonwords which are graded in difficulty. The first 10 items are one syllable in length and the remaining items are 2 syllables long. The child scores 1 for a correct response and 0 for an incorrect response. The total possible is 24.

**(iv). Rhyme Production** The rhyme production test from the Phonological Abilities Test (Muter, Hulme & Snowling (1997), was used. This test in described fully in the method section of Chapter 2. However, 2 additional target items were used here in order to prevent any possible ceiling effects. Again with these items children were asked to provide as many words or nonwords to rhyme with the target word as possible in a 30 second period.

**(vi). Rhyme Detection** As above this task was taken from the Phonological Abilities Test and is described in Chapter 2. The first 10 items came from this test but again additional items were added to this set. These items were presented without pictures, the children being asked to decide which two words, from a possible three, rhymed. The total number of items presented was 24, giving a maximum possible score of 24.

**(vii). Phoneme Deletion** The first 18 items of this task were taken from the Phonological Abilities Test, a further 18 items for initial phoneme deletion and a further 18 items for end phoneme deletion were also used. These additional items were presented without pictures. The total possible score for this task was 54. The test was discontinued after four consecutive errors.

**(viii). The English Picture Vocabulary Test** In this vocabulary test (Brimer & Dunn, 1973) the child is shown a set of four pictures and asked to point to the picture which corresponds to a word. There are 3 practice items and 120 test items. Testing is discontinued after 5 errors are made in 8 consecutive items. One point is given for each correct item, the maximum possible score being 120.

**(ix). Matrices Task** This task was devised by Hatcher, Hulme & Ellis (1994). In this test the children are shown a set of squares each with a pattern in and are required to pick out, from a set of cards, the card which is needed to fill a blank square and complete the pattern. The final seven items of the test require the child to actually draw in the missing shape to complete the pattern. Testing is discontinued after five consecutive errors. The maximum possible score is 20.

**(x). IQ** An estimate of IQ was devised using the scores from the Vocabulary Test and the Matrices task. This was done by creating four age groups of children. The scores form the English Picture Vocabulary Test and the Matrices test were converted into standard scores. These standard scores were then added and the sum was divided by two, giving an average standard score. The average mean score was subtracted from this average standard score and this figure was then divided by the average standard deviation. To this figure was added 100, creating the IQ score.

**(xi). The Cue Learning Task** In addition to these general language tasks, the participants took part in a paired associate learning task over two consecutive days. This cue learning task was very similar to the task in Experiment 6, although some of the items and some aspects of the procedure were changed. The child's task was to learn to associate abbreviated cues with spoken words. Twenty target-cue pairings were learnt in two blocks of ten over two days of testing.

The target words were all bisyllabic words with a CVCVC or CVCV phonemic structure. All the words had previously been used in Experiment 6, therefore, the ratings from this experiment were used. However, in this experiment 10 words, as opposed to 12 words were included in each condition. The inter-rater reliability of the ratings for these 10 words was examined and was found to be high. For imageability ratings, Alpha= .98, for familiarity, Alpha=.87 and for age of acquisition, Alpha=.88.

For the purposes of this study, high-imageability is defined as words with a mean rating <4.4 and low-imageability is defined as >3.6. Age of acquisition, familiarity, the number of letters and phonemes in the words in each condition was controlled for. The properties of the two groups of high and low-imageability words, are presented in Table 6.2 below. The ratings for each word in the experiment are listed in Tables 5.2 and 5.3 in Chapter 5.

**Table 6.2**

Table showing the properties of the two word groups

| Group | Imag. | Famil. | Age/Ac. | Letter | Phoneme |
|---|---|---|---|---|---|
| High M | 5.8 | 3.6 | 2.6 | 5.9 | 4.7 |
| SD | 0.7 | 3.6 | 0.7 | 0.3 | 0.7 |
| Low M | 2.5 | 3.6 | 2.7 | 5.6 | 4.6 |
| SD | 0.8 | 0.5 | 0.3 | 0.7 | 0.7 |

In order to confirm that the two word groups differed only in their imageability the data were subjected to analysis of variance. This analysis showed that the word groups differed in their imageability ($F(1,19)=88.01$, $p<.001$) but not in their age of acquisition ($F(1,19)=.02$, $p>.05$), familiarity ($F(1,19)=.09$, $p>.05$), number of letters ($F(1,19)=.51$, $p>.05$) or number of phonemes ($F(1,19)=.41$, $p>.05$).

The same cues and words as had been used in Experiment 6 were used in this experiment. The way in which these cues are created is described fully in previous chapters. The experiment included four word groups, high-imageability phonetic, high-imageability control, low-imageability phonetic and low-imageability control. The target words, and their cues used in this experiment are listed in Table 6.3.

Two forms of the experiment were constructed so that each target word appeared in each form once in either the phonetic or control condition. A target word appeared in each form once in each condition, so if 'wizard' appeared as 'wsd' in one form it would appear as 'wfd' in the other form. Each form of the experiment contained 20 words, 10 phonetic cue words and 10 control cue words. The cues were then grouped in two blocks of ten. The child was presented with one block on day one of testing and the second block on day two of testing, different cues were learnt on each day. The order of presentation of each of the word groups was counterbalanced.

**Table 6.3**

Cues Created for Items in Experiment 7

| High-imageability | Phonetic | Control |
|---|---|---|
| rabbit | rpt | rgt |
| bottle | bdl | bpl |
| wizard | wsd | wfd |
| jacket | jgt | jpt |
| robber | rpr | rgr |
| ladder | ltr | lkr |
| river | rfr | rzr |
| coffee | kvi | kzi |
| ticket | tgt | tpt |
| basket | bzkt | bfkt |

| Low-imageability | Phonetic | Control |
|---|---|---|
| noisy | nzi | nfi |
| heavy | hfi | hzi |
| listen | lzn | lfn |
| visit | vzt | vft |
| ready | rti | rki |
| because | bgs | bps |
| hidden | htn | hgn |
| never | nfr | nzr |
| middle | mtl | mkl |
| trouble | trpl | trgl |

### 6.2.2.3 Procedure

All of the language tasks described above were administered at time 1, while the children were in the reception class. It was their performance in these tasks which allowed for the formation of groups of good and poor beginning readers. These tasks were administered individually by research assistants working on a separate project.

A number of these tasks were also administered at time 2, the time of the present study, these were: BAS single word reading, the Early Word Recognition test, The Graded Nonword Reading Test, and Letter Knowledge. These tests were given on the first day the child was seen, before the cue learning task. The children were all seen individually in a quiet area outside their classroom. The cue learning task was administered over two consecutive days. Testing began when the children had completed all the tasks described above.

### 6.2.4 Results

#### 6.2.4.1 Comparing the learning of the cues

The results of the cue learning task are given first. In this task the child was given a score from 0 to 6, with one point for each correct recall of the associated target word. With five items in each condition, the maximum possible score for each of the four word groups is 30, giving a total maximum score of 120 across all conditions. The performance of the good and poor beginning readers in each of these conditions is presented in Table 6.6

**Table 6.4**

Mean values and Std. Deviations for Cue Learning for each Reader Group

| | Imageability | Phonetic | Control |
|---|---|---|---|
| Good | High | 23.6 (3.1) | 15.4 (5) |
| | Low | 18.9 (5.6) | 9.7 (5.2) |
| Poor | High | 15.8 (4.7) | 10.6 (3.7) |
| | Low | 5.4 (4.4) | 3.5 (3.2) |

As can be seen from the table, the poor beginning readers learnt fewer cues over the two days than the good beginning readers. A within subject analysis of variance revealed a significant difference in the number of cues learnt overall between the good and poor reader group ($F(1,35)=57.61$, $p<.001$). The good readers learnt almost twice as many cues as the poor reader group.

The table also shows that both groups, with both high and low-imageability cues learnt phonetic cues more easily than control cues. Further, both groups, with both phonetic and control cues learnt high-imageability cues more easily than low-imageability cues. Hence both a phonetic cue effect and an imageability effect appear to influence the learning of good and poor readers.

A within subjects analysis of variance confirms this. The within subject factors in the analysis were Cue Type (phonetic vs. control) and Imageability (high vs. low) and the between subject factor was Group (good vs. poor). The analysis showed a strong main effect of cue type ($F(1,34)=63.7$, $p<.001$), a strong main effect of imageability ($F(1,34)=209.8$, $p<.001$) and a strong main effect of group ($F(1,34)=57.3$, $p<.001$). This verifies that the phonetic quality of a cue, its imageability and the child's level of reading attainment all influence cue learning. However, these factors also interact with each other. Firstly, there is a significant group by imageability interaction ($F(1,34)=13.8$, $p<.001$); the mean scores suggest that the poor readers show a stronger imageability effect than the good readers. Secondly, there is a group by type interaction ($F(1,34)=11$, $p=.002$). The mean difference between the phonetic cue score for the good readers is 17.6 (SD 9.9) and for the poor readers is 7.2 (SD 8.6), suggesting that the good readers show a stronger phonetic cue effect. There is also a significant three way group by imageability by type interaction, ($F(1,34)=5.31$, $p<.05$). However, the imageability by cue type interaction is not significant ($F(1,34)=1.5$, $p>.05$), the means suggest that the imageability effect does not differ across the cue type condition.

To explore the 3 way interaction further, separate 2 way ANOVAs were calculated for the two groups. The good reader group showed a main effect of imageability ($F(1,17)=39.85$, $p<.001$) and a main effect of cue type ($F(1,17)=56.63$, $p<.001$). However, no significant imageability by type interaction was found ($F(1,17)=.32$, $p>.05$). In contrast, the poor reader group showed a main effect of imageability ($F(1,17)=265.7$, $p<.001$), a main effect of cue type ($F(1,17)=12.4$, $p<.001$), as well as showing an interaction between imageability and type ($F(1,17)=8.36$, $p<.05$). This interaction would seem to be accounted for by the fact that the poor readers do not show a phonetic cue effect for the low-imageability words, this may be the result of very low performance overall with the low-imageability words.

A by-items analysis of variance was conducted in order to confirm the generality of effects across items as well as subjects. The mean scores for each of the item groups are presented in Table 6.7.

**Table 6.5**

Mean scores of items in all conditions

| | | Phonetic | Control |
|---|---|---|---|
| Good Readers | High Im. Items | 4.7 (0.8) | 3.1 (0.9) |
| | Low Im. Items | 3.8 (0.9) | 1.8 (0.9) |
| Poor Readers | High Im Items | 3.4 (1.1) | 2.1 (1.3) |
| | Low Im. Items | 1 (0.8) | 0.7 (0.6) |

max poss score= 6

Again, there were two factors in the analysis, Imageability and Cue Type. A main effect of imageability, ($F(1,18)=20.5$, $p<.001$) and a main effect of cue type ($F(1,18)=60.6$, $p<.001$) was found. There was also a strong main effect of group ($F(1,18)=98.9$, $p<.001$), as well as a strong interaction between group and cue type ($F(1,18)=21.7$, $p<.001$). The interaction between imageability and group was significant ($F(1,18)=7.1$, $p<.05$). A significant three way interaction between imageability, group and cue type was also found ($F(1,18)=8.98$, $p<.05$). However, as was the case with the subject analysis the cue by imageability interaction was not significant ($F(1,18)=96$, $p>.05$).

These effects across items were also found for the two groups separately. The items for the good reader group showed a main effect of imageability ($F(1,18)=9.7$, $p<.05$) and a main effect of cue type ($F(1,18)=110.4$, $p<.001$), but no cue type by imageability interaction ($F(1,18)=.89$, $p>05$). The items for the poor reader group showed a main effect of imageability ($F(1,18)=25.7$, $p<.001$) and a main effect of cue type ($F(1,18)=12.6$, $p<.001$), but also showed a significant cue type by imageability interaction ($F(1,18)=4.81$, $p<.05$). These item analyses simply confirm the pattern of findings in the by-subject analysis.

#### 6.2.4.2 The relationship between learning and the language measures

The mean scores on the language tests administered at time 2 are given in Table 6.6 below.

**Table 6.6**

Performance on Language Tasks at Time 2

| | BAS | EWR | Letter | Nonword |
|---|---|---|---|---|
| Good M | 24.4 | 35.6 | 25.9 | 8.8 |
| SD | 10.6 | 5.5 | .32 | 4.1 |
| Poor M | 2.2 | 9.1 | 21.3 | .72 |
| SD | 2.5 | 5.9 | 4.5 | 1.9 |

It can be seen from Table 6.6 that there are still considerable differences between the two groups, with the good reader group outperforming the poor reader group on all the measures. It was shown in Experiments 1-6 that these independent measures of reading and phonological skill strongly predicted overall cue learning. The same relationship was examined here. The table below shows the correlations between language measures taken at time 1 and 2 and overall cue learning ability for both groups combined. The second line of the table shows partial correlations between overall learning ability and the language measures when age is controlled for.

**Table 6.7**

The Relationship between Cue Learning and Language Measures at Time 1

| | age | IQ | BAS1 | EWR | rhyd1 | phb1 | phe1 | lett1 | rhyp1 | nw |
|---|---|---|---|---|---|---|---|---|---|---|
| Cue Score | .29 | .01 | .70** | .77** | .64** | .61** | .34* | .65** | .49* | .35* |
| | | .09 | .68** | .75** | .62** | .57** | .33* | .62** | .46* | .33* |

key: EWR= Early Word Recognition, rhyd= rhyme detection, phb= phoneme deletion, letter= letter knowledge, rhyp= rhyme production, nw= nonword

**Table 6.8**

The Relationship between Cue Learning and Language Measures at Time 2

| | nonw3 | BAS2 | EWR2 | lett2 |
|---|---|---|---|---|
| Cue Score | .61** | .75** | .87** | .70** |
| | .56* | .73** | .86** | .67** |

*=p<.05; **=p<.001

It can be seen from Table 6.7 that overall cue learning is strongly correlated with all the measures that were taken a year prior to the cue learning experiment, at time 1. However, cue learning is not significantly related to age or general intelligence. Cue learning is strongly correlated with the measures taken at time 2, indeed the relationship between learning and these tasks seems to be stronger, this is perhaps not surprising given that the measures were taken at the same time as the cues were learnt.

The relationship between children's ability to learn to read the high-imageability words, when their learning of the low-imageability words is controlled for, and these language measures is examined below. By controlling for the low-imageability imageability learning scores it is possible to examine the extent to which children's sensitivity to imageability is related to their performance on the independent language measures. This procedure was described fully in Chapter 2. The first line of Tables 6.9 and 6.10 show the correlations between the high-imageability score and the languages measures when the low-imageability score is controlled for. The second line of the tables shows these correlations when age is also controlled for.

**Table 6.9**

The Relationship between the High-imageability Score and Language and Reading Measures at Time 1

| | age | IQ | BAS1 | EWR1 | rhyd1 | phe1 | phb1 | letter1 | rhyp1 | nonw1 |
|---|---|---|---|---|---|---|---|---|---|---|
| High[1] | -.15 | .02 | .12 | .28 | .21 | .17 | -.02 | .08 | .12 | 0 |
| 2 | | -.02 | .10 | .29 | .21 | .17 | 0 | .10 | .11 | 0 |

key: EWR= Early Word Recognition, rhyd= rhyme detection, phb= phoneme deletion, letter= letter knowledge, rhyp= rhyme production, nw= nonword

**Table 6.10**

The Relationship between the High-imageability Score and Language and Reading Measures at Time 2

| | nonw3 | BAS2 | EWR2 | letter2 |
|---|---|---|---|---|
| High[1] | .02 | .12 | .29 | .16 |
| 2 | -.03 | -.12 | .33* | .16 |

*=p<.05; **=p<.001

[1]controlling for the low imageability score [2]controlling for the low imageability score and age

The tables above show that the extent to which children learn high-imageability words more than low-imageability words is not significantly related to the independent language measures. These correlations do not support the hypothesis proposed here that children with good reading and phonological skills are less influenced by imageability. It is possible that the imageability effect, when measured in this way, is not strong enough to correlate with these measures. However, there is some evidence to support the hypothesis. If the correlations between learning the low-imageability words and the language measures are examined when the high-imageability score is controlled, for the pattern of results looks slightly different.

**Table 6.11**

The Relationship between the Low-imageability Score and Language and Reading Measures at Time 1

| | age | IQ | BAS1 | EWR1 | rhyd1 | phe1 | phb1 | letter1 | rhyp1 | nonw1 |
|---|---|---|---|---|---|---|---|---|---|---|
| Low[1] | .17 | -.02 | .36* | .33* | .23 | .02 | .40* | .35* | .19 | .20 |
| 2 | | .07 | .37* | .30 | .21 | .02 | .36* | .31 | .16 | .19 |

key: EWR= Early Word Recognition, rhyd= rhyme detection, phb= phoneme deletion, letter= letter knowledge, rhyp= rhyme production, nw= nonword

**Table 6.12**

The Relationship between the Low-imageability Score and Language and Reading Measures at Time 2

| | nonw3 | BAS2 | EWR2 | letter2 |
|---|---|---|---|---|
| Low[1] | .40* | .43* | .54** | .38* |
| 2 | .32 | .41* | .49* | .31 |

*=p<.05; **=p<.001

[1]Controlling for high imageability score

[2]Controlling for high imageability score and age

Children's ability to learn to read the low-imageability words correlates strongly with their reading skills and letter and phonemic awareness, even when their learning of the high-imageability words is controlled for. This suggests that children with poor reading skills and phonemic awareness will have particular difficulty with these words.

The relationship between these independent language measures and the learning of the phonetic and control cues is examined below. Again it is argued that by examining the relationship between the phonetic cue score and the language measures, while controlling for the control cue score, it is possible to examine the extent to which children's sensitivity to the phonetic quality of the cue is related to their reading and phonological skills. The tables below show the correlations between the language tasks done at times 1 and 2 and the phonetic cue score. The second line of the table shows partial correlations, with age also being controlled for.

**Table 6.13**

The Relationship between the Phonetic Cue Score and Language and Reading Measures at Time 1

| | age | IQ | BAS1 | EWR1 | rhyd1 | phe1 | phb1 | letter1 | rhyp1 | nonw1 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Phon cue**[1] | .37* | -.19 | .62** | .71** | .36* | .44* | .65** | .30 | .32** | .60** |
| 2 | | -.09 | .69** | .69** | .33 | .46* | .62** | .24 | .34* | .61** |

**Table 6.14**

The Relationship between the Phonetic Cue Score and Language and Reading Measures at Time 2

| | nonw3 | BAS2 | EWR2 | lett2 |
|---|---|---|---|---|
| **Phon cue**[1] | .69** | .65** | .83** | .56** |
| 2 | .63** | .64** | .81** | .48* |

*=p<.05; **=p<.001

[1]Controlling for control cue score [2]Controlling for control cue score and age

It can be seen that the extent to which the phonetic cues were learnt more easily than the control cues is significantly related to measures taken at times 1 and 2. There is a strong positive relationship between reading ability and the tendency to show the phonetic cue effect, this is shown by the correlations with BAS, EWR and Nonword reading. This corresponds to the finding that the good readers showed a stronger phonetic cue effect than the poor readers.

### 6.2.5 Discussion

The results of this study suggest a number of things about the early word learning of good and poor beginning readers. Firstly, and not surprisingly, the good readers, with good phonological skills, learn more cues overall than the poor readers. Together with the results of Experiment 1, this finding provides further support for the validity of the learning measure used as being analogous to the process of learning to read words. Secondly, both groups showed an imageability effect and a phonetic cue effect, suggesting that beginning readers as a whole are influenced by both phonological and semantic factors in their early word reading. This confirms the findings of the previous experiments.

However, as predicted in the introduction, it was found that the good readers showed a stronger phonetic cue effect, suggesting a greater sensitivity to the phonemic overlap between the cues and their target words than the poor readers. Similarly, the poor readers relied more on the semantic information in the cues than the good readers. Finally, it was shown that the overall rate of learning and the sensitivity to both effects was predicted by independent measures of phonological skill. The tendency to show a phonetic cue effect was shown to be strongly related to phonological awareness skill, reading and nonword reading ability. It was also shown that children's ability to learn low-imageability words is more strongly related to their phonological and reading skills than their ability to learn to read high-imageability words.

The fact that the poor readers in the present study showed a stronger imageability effect than the good readers is consistent with previous studies (Jorm, 1977; Coltheart et al., 1988). However, the present study used children in the very early stages of reading development and differs in examining word learning, as opposed to recognition or recall. In these previous studies it was found that imageability influenced only the performance of poor readers and that any imageability effects seen in other readers were shown to be accounted for by differences in age of acquisition. However, in the present study the items to be learnt were matched in terms of their age of acquisition and so the imageability effect cannot be explained by differences in age of acquisition. Furthermore, although the poor readers showed a larger imageability effect, it was still the case that the better readers showed an imageability effect. This is consistent with the findings of the earlier experiments which showed that beginning readers of average reading ability are influenced by semantic variable imageability in their early word learning.

One reason why imageability was shown to influence both good and poor readers in the present experiment may be that different processes are involved in the learning of novel items from those involved in word recognition. As discussed in Chapter 5, considered in terms of a connectionist model, recognition involves the activation of existing connections between units whereas learning involves the establishment of these connections. The Plaut et al. (1994) model which predicts a division of labour between phonology and semantics is based on a model of word recognition. Plaut et al. suggest that the semantic pathway does not make a significant contribution until the phonological pathway has developed to some degree. Therefore, during the learning phase no such interaction is observed. While the results of Experiments 6 and 7 suggest that the semantic pathway is an important part of learning much earlier than supposed by Plaut et al., it is the case that developmental factors may determine the presence or absence of an imageability effect and the extent to which it interacts with phonological factors. If the interaction between semantics and phonology is viewed as a division of labour, then imageability would be predicted to influence word recognition only in certain circumstances, that is, when orthographic to phonological translation is difficult. Older children, who have developed reasonable phonological skills, would be unlikely to show imageability effects except with words in which this translation is difficult, for example with low frequency, exception words. Strain et al. (1995) showed that with these types of words even adults will show imageability effects when reading words. However, the notion of a division of labour between phonology and semantics would predict that semantics would have a strong influence on the word learning of all beginning readers because all of them have limited phonological skills.

It has been argued in studies of memory development that poor readers are more likely to depend on a semantic code, if available (Byrne & Shea, 1979; Vellutino & Scanlon, 1985). It would seem that when stimuli containing both phonological and semantic elements must be coded, the poor readers with poor phonological skills, show greater dependence on semantic processing. The fact that the poor readers in this study still show a phonetic cue effect suggest that they are not exclusively dependent on semantics and must first access some phonological information in their word learning. In this sense it is seen phonological and semantic factors interact with one another in influencing word learning, as would be suggested by the Plaut et al. model. However, it does also seem to be the case that the poor readers are more influenced by the semantic quality of a word when learning to read it. Many of the poor readers had difficulty in learning any low-imageability words at all, and most of them showed very strong imageability effects.

The fact that the good reader group showed a stronger phonetic cue effect than the poor readers and the fact that they showed much less of an imageability effect suggests that they are more sensitive to the phonetic information in a word and are able to use this information to set up efficient mappings between orthography and phonology. It is argued here that because the good reader group are better at using phonological information in their learning they have less need to depend on semantic factors, that is, their representations of the cues are enough to aid recall and so the semantic quality of the cue has less of a part to play. It is clear that the ability to access this phonetic information and use it to form connections between print and spoken pronunciations is a more effective learning strategy and results in more cues being learn overall. The studies discussed in the introduction provide good evidence that the phonological representations the good readers develop are more complete than those of the poor readers (Ehri & Saltmarsh, 1995). The findings of the present experiment also suggest that they are more sensitive to the phonemic overlap between letters in the cue and letters in the target word. Furthermore, there is also evidence that good readers will be more attentive to the medial letters in the words they are learning than poor readers who will tend to be more sensitive to the initial and final letters (Stuart & Coltheart, 1988). Given that the ability to show a phonetic cue effect is dependent on the analysing of the medial letter in the cue, it is perhaps unsurprising that the good readers are more sensitive to the cue than the poor readers.

It is also important to note that the poor readers still showed a phonetic cue effect and this finding is consistent with the previous experiments which suggest that even children at the very beginning stages of reading development are sensitive to the phonetic quality of a word and will show a phonetic cue effect. It is not the case therefore that these poor readers are using a whole word 'logographic' strategy to learn these cues. However, it may be that their poor phonological skills make them less analytic of the cues to be learnt.

The results of Experiment 7 can be compared with those of Experiment 1. In Experiment 1 children's ability to learn to associate 3 letter cues with spoken words was also examined. In that experiment children in three age groups were studied. If the hypothesis of Experiment 7 is correct it might be predicted that in Experiment 1, the older children, who had better phonological skills, would show a stronger phonetic cue effect than the younger readers. While a trend in this direction was found, with children showing an increasingly stronger phonetic effect with age, this trend was not significant. There are a number of possible reasons which may suggest why the results of Experiments 1 and 7 were not more similar. Firstly, an important difference between Experiments 1 and 7 is that Experiment 7 compared the performance of good and poor beginning readers, while Experiment 1 examined the learning of average beginning readers. It is possible that the children in Experiment 7 have particularly impaired phonological skills which would mean that the difference between the phonetic cue effect shown by the good and poor beginning readers would be larger. The difference in reading and phonological skills between the good and poor readers in Experiment 7 is greater than the difference between the year groups in Experiment 1. However, if the comparison is made between the reception children (whose reading is at a comparable level as the poor readers in Experiment 7) and the children in Year 2 then a similar pattern of results is seen , the Year 2 children show a much greater phonetic cue effect than the reception children.

A second reason which may account for differences in the two experiments is the amount of variation in performance in the cue learning task observed, the variation is much greater for the children in Experiment 1 than it is in Experiment 7. It is possible that the degree of variation in Experiment 1 masks possible differences in the cue effects observed in Experiment 7. Furthermore, the children in Experiment 7 appear to show a stronger phonetic cue effect overall than the children in Experiment 1; this may be due to the items used or the teaching method the children received. The fact that a stronger effect overall was found in Experiment 7 may, in part, explain bigger differences in effect size between good and poor readers. Thirdly, Experiment 7 differs from Experiment 1 in varying the semantic quality of the words learnt. In Experiment 1 imageability is controlled, all the words are relatively high in imageability; in Experiment 7 imageability is varied so that some words are high in imageability and some are low in imageability. It is possible that the poor readers in Experiment 7 focus on the semantic coding of words, as suggested by studies of short-term memory, and therefore show much less of a phonetic cue effect than normal beginning readers and hence a bigger difference is seen between the good and poor readers.

One important limitation of this study is that it is not clear whether the cue learning of the poor readers in this experiment is particularly impaired or whether it is a function of their level of reading development. It is unclear whether younger children reading at the same level as these poor readers would show the same pattern in their learning. Ehri & Saltmarsh (1995) found in their study of word learning that it was the older disabled readers who had the greatest problems in forming lexical representations of the words to be learnt, and in this respect differed from a group of novice beginning readers. It could be that in this study the poor readers are in actual fact not dissimilar to novice beginning readers. Further research would be needed in order to consider the ability of children with more profound reading problems, such as dyslexics, to learn to read these cues.

### 6.2.6 Overall Summary and Conclusions

This chapter reported the results of an Experiment which examined the role of phonological and semantic factors influencing children's ability to learn to read. The experiment used the same paradigm as previous experiments in examining the ability of children to learn to associate three letter cues with target words. Experiment 6 had found that phonological and semantic factors had independent influences on children's ability to learn to read these cues. Experiment 7 considered the relationship between phonological and semantic factors further by considering the learning of good and poor beginning readers. Experiment 7 found that beginning readers were influenced by both the phonological and semantic quality of the words they were learning. They learnt cues which were phonetically similar to the target words more easily than cues which were not phonetically similar. Words which were high in imageability were learnt more easily than low-imageability words. These results confirmed the findings of experiments 1-6.

However, Experiment 7 also showed that phonological and semantic factors have a different effect on the performance of good and poor beginning readers. It was found that the poor beginning readers were more influenced by the semantic quality of the words they were learning, the poor readers showed a stronger imageability effect than the good readers. This finding confirms the results of Experiment 6 which also found a trend in this direction. Experiment 7 also found that the good readers were more influenced by the phonological quality of the cues they were learning, the good readers showed a significantly stronger phonetic cue effect than the poor readers. This finding suggests that the good readers are more sensitive to the phonology of words they learn to read. The fact that the good readers learnt more cues overall suggests that theirs is a more effective and systematic method of learning.

# Chapter Seven

# Summary, Conclusions and Implications

## 7.1 Summary of Findings

This chapter will first provide a summary of the main results reported in this thesis. These results will then be discussed in the light of previous research on children's early reading development and in the light of models of reading development proposed to date. Finally, the implications of this research for future research and for educational practice will be considered.

Chapter 2 presented an experiment in which four, five and six-year-old children were taught to associate three-letter abbreviated words with spoken target words. It was argued that learning to read these three letter 'cues' was analogous to the processes involved in learning to read words in the very early stages of reading development. It was found that children learnt the cues that were phonetically similar to the spoken target word more easily than the cues that were less phonetically similar to the target word. This finding suggests that children are sensitive to the phonological make-up of words they learn to read from a very early stage of reading development. These results pose some problems for traditional stage models of reading development which suggest that children at this stage learn to read words on the basis of salient visual features and do not process phonological information. These results also challenge the notion that the first units of phonology children are able to access are onset and rime units (Goswami & Bryant, 1990). The children in Experiment 1 are able to access and use very small units of phonology and are sensitive to phonetic information at a featural level. Whereas previous studies have considered the metacognitive awareness of phonology, the use of phonology in this experiment is clearly implicit, this distinction may explain these contradictory findings.

Children's implicit use of phonology in Experiment 1 was related to their performance on explicit phonological awareness measures. Phonological awareness skills were strongly related to the ability to learn to read the cues and phonemic awareness was a particularly strong predictor of word learning. Knowledge of the meanings of the target words to be learnt was also found to be a strong predictor of the ease with which children would learn to associate the cues with the target words.

Chapter 3 presented a series of experiments which examined the influence of the phonological and semantic qualities of words which children were taught to read. In Experiment 2 five-year-old children were taught to read a series of words which differed in their imageability and in their regularity. It was reasoned that if children at this stage were accessing phonological information and using it to form connections between print and its pronunciation, they would learn to read regular words more easily than irregular words. Similarly, it was suggested that if the semantic quality of a word is an important predictor of the ease with which children will learn to read it then high-imageability words would be learnt more easily than low-imageability words. Half of the words in the experiment were high in imageability and half were low in imageability, the two sets of words were matched for number of letters and phonemes, familiarity, and age of acquisition. Children did indeed learn to read the words high in imageability much more easily than the low-imageability words.

Experiment 3 showed that this imageability effect was not just an effect of a bias towards words from a particular grammatical category. When grammatical class was controlled for, by selecting only verbs, a strong imageability effect on word learning was still found. However, no effect of regularity was found, children did not learn to read regular words more easily than irregular words. The definition of regularity used in this experiment was the same as that used by Rack et al. (1994). Rack et al. had found that beginning readers learnt to read 'transparent' words more easily than 'opaque' words. Transparent words were words which contained letters which all corresponded to a sound in the word's pronunciation and the sound represented by each letter corresponded to the most frequent or typical sound for that letter in English. Opaque words contained at least one letter that did not correspond to a sound in the word's pronunciation or contained a letter that was assigned an atypical or low-frequency pronunciation. No such effects of transparency were found in Experiment 2 and furthermore when a direct replication of the Rack et al. study was undertaken in Experiment 2(b) there was also no effect of regularity was found. The influence of regularity, as measured in this way, does not have a robust effect on the ability of beginning readers to learn to read words. However, it was argued that this did not rule out the possibility that beginning readers are influenced by regularity when a different definition of regularity is used.

Chapter 4 further investigated the influence of regularity on children's ability to learn to read a set of words. It was suggested that one reason for the lack of an effect of regularity on word learning found in Experiment 2 might have been due to the nature of the irregularities in the items used in the experiment. The irregularity of the words in Experiments 2 almost always lay in the vowels, while the consonants remained regular. It was argued that if children in the early stages of reading are able to form connections, or partial connections, between some letters in a word and the word's pronunciation, as suggested by Ehri (1992) and by the results described above, consonants may be more important in this process than vowels. There is good evidence to suggest that children are able to represent consonants more consistently than vowels (Stuart & Coltheart, 1988; Ehri, Taylor & Wilce, 1995). It is reasonable to propose, therefore, that if children rely on consonants, particularly those in boundary positions in forming associations between print and its spoken form, then irregular consonants in a word would be likely to impede the establishment of connections between the printed and spoken word. All of the items in Experiments 4 and 5 were irregular in terms of their consonants. Unlike the results of Experiment 2, a strong effect of regularity was found on children's ability to learn to read words.

Experiments 4 and 5 also considered the relationship between children's ability to learn to read words and their performance on a range of phonological and semantic tasks. Some of these tasks were based on the words which were subsequently to be learnt and some were based on other words unrelated to the word learning task. It was thought possible that tasks based on the words to be learnt would be stronger predictors of word learning than the tasks based on other words. This was not found to be the case, both tasks were equally predictive of word learning. In these experiments the phonological measures were much stronger predictors of word learning than the semantic measures, phonemic awareness was shown to be particularly important. Unlike in previous experiments the semantic measures were relatively unrelated to word learning, however, as suggested in Chapter 4, there were a number of problems with these semantic measures.

The possible interactive relationship between phonological and semantic influences in beginning reading was examined in Chapters 5 and 6. In Experiment 6 five-year-olds were taught to associate three letter cues with target words, using the same paradigm as Experiment 1. As in this earlier experiment half of the cues were 'phonetic cues' and half were 'control cues'. The words also differed in their imageability; half being high-imageability and half low-imageability. There were, therefore, four types of cue in the experiment; high-imageability phonetic, high-imageability control, low-imageability phonetic, low-imageability control. The children in Experiment 6 were influenced by the phonetic quality and the imageability of the cues: phonetic cues were learnt more easily than control cues and the high-imageability cues were learnt more easily than the low-imageability cues. No interaction was found between these two factors, suggesting that phonological and semantic factors make independent contributions to reading in the very early stages of reading development. It is possible that an interaction is not found in the word learning of children at this level of reading performance because neither pathway is sufficiently developed to allow such an interaction to be observed. It is hypothesised that partial activations between print and both the phonological and semantic systems are important in early word learning.

Another way of conceptualising an interaction between phonology and semantics is in terms of a deficit in processing in one pathway. It is possible that a deficit in one pathway would lead to an over dependence on the contribution from the other pathway, this is predicted by the connectionist model of Plaut et al. (1996) who suggested a 'division of labour' between phonology and semantics. A trend towards such an interaction had been observed in Experiment 6 when the good and poor readers were examined separately. It was found that the poor readers, who had poor phonological skills, relied more on the semantic quality of the words they were learning and showed a stronger effect of imageability in their word learning. This differential use of phonological and semantic cues in early word learning was examined more systematically in Experiment 7. In this experiment, 36 children aged between 5 and 6 years old were taught the four types of cues used in Experiment 6. Half of the children in the experiment were poor beginning readers and half were good beginning readers, the two groups did not differ in their level of general intelligence. Both groups of readers were shown to be influenced by both the imageability and the phonological quality of the words they were learning. However, the poor readers were more influenced by the semantic quality of the words they were learning and showed a stronger imageability effect. The good readers showed less of an imageability effect but showed a stronger phonetic effect, suggesting a greater sensitivity to the phonological quality of the word. It would seem that while both phonology and semantics has an influence on beginning reading the exact nature and extent of these influences is to some extent mediated by level of reading development and phonological skill.

In summary, the experiments reported in this thesis have shown that children can use phonological and semantic information to form connections between the spoken and written forms of words from a very early stage of reading development. Their ability to access and use phonological information implicitly in word learning was also found to be strongly related to their explicit phonological awareness skills. Phonological and semantic factors seem to make independent contributions to children's word learning at this stage although an impairment in one pathway would seem to lead to a greater dependence on the other pathway.

## 7.2 Theoretical Issues

### 7.2.1 Children's Use of Phonology in their Early Word Learning

Traditional stage models of reading development have proposed that children initially learn to read words using a whole word or 'logographic' strategy, that is, they are influenced by the visual and not phonological features of words in learning to read them. According to such models it is not until children have 'cracked the alphabetic code' that they begin to use letter-sound information to decode words in a left to right fashion. As suggested in Chapter One, there is good evidence to suggest that children might be sensitive to the phonological structure of the words they learn, much earlier on. For example, children with good pre-reading phonological skills tend to make more reading errors suggesting the early use of phonology in word learning (Stuart & Coltheart, 1988).

The work of Ehri (1987, 1992) also suggests that although children may use a visual strategy in the very early stages of reading development, they very soon begin to use their limited knowledge about letter-sound relations to form connections between print and its spoken form. Ehri argues that children in the early stages of reading development engage in 'phonetic cue reading'. That is, they form partial connections between some letters in a word and the word's pronunciation before they are able to generate all the letters in a word and decode in a letter by letter fashion. In a similar vein, Rack et al. (1994) propose a 'direct mapping mechanism', arguing that children in the early stages of reading development learn the pronunciation of a word not by applying letter-sound knowledge sequentially but by accessing partial information from some of the letters in the word. This work suggests that children are able to use stored letter-sound associations before developing explicit decoding skills.

The results of this thesis support the idea that children are sensitive to the phonetic structure of words from a very early stage of learning to read. Experiments 1 and 6 clearly demonstrated that beginning readers learnt to associate abbreviated words or 'cues' more easily with target words when they were phonetically more similar to the target words than when they were less similar. These findings suggest that children are sensitive to the degree of phonetic overlap between the cues and the target words and are able to use this knowledge in their learning. The children in these experiments were unable to decode even simple words and, therefore, cannot be said to be using an alphabetic strategy. Learning, in these experiments, was taking place by a process of direct mapping, as suggested by Rack et al. rather than by children explicitly decoding words in a sequential letter by letter manner.

As well as showing a sensitivity to the phonological quality of words in this cue learning task, children were also shown to be sensitive to letter sound regularity in a word learning task. Although a regularity effect was not found in Experiment 2, it was found in Experiments 4 and 5. It was argued that if children in the very early stages of reading development use partial letter information to learn to read words, then irregularities in certain types of letter-sound information may impair learning performance. It has previously been shown in speech perception and production tasks that children's representation of consonants is far more consistent than their representation of vowels; it is therefore more likely that consonants will be used in word learning than vowels and therefore irregular consonants may make learning particularly difficult. This was found to be the case even for children in the very earliest stages of reading development, children who were not yet decoding words. Words containing irregular consonants were learnt less well than words with regular consonants. This difference between words which are irregular in their consonants and words which are irregular in their vowels can be seen in a word such as biscuit; if children are forming a partial association between some of the letters in the word biscuit and its pronunciation and they are more likely to use consonants, in particular consonants in boundary positions, for this task then the irregularity in biscuit becomes less important. It is possible that 'bsct' is enough information to set up an association between the word and its pronunciation. The fact that children in this initial stage of reading development learnt regular words more easily than irregular words suggests that they are sensitive to the words' phonology much earlier than would have been predicted by traditional stage models.

The results of these experiments are well accommodated within a connectionist model of reading development. Seidenberg and McClelland (1989) developed a model which learns the mappings between sequences of letters and their pronunciations, these mappings operate automatically and unconsciously in word recognition. In this model a single mechanism is involved in word recognition from the start, no separate decoding mechanism is needed. Learning is achieved without the need for word-level representations or for the programming of explicit pronunciation rules. An important feature of the model is the way in which phonology is represented. The model employs featurally-based distributed representations of phonology and would therefore be expected to be sensitive to similarities between sounds. In such a system similar sounds, for example /k/ and /g/, have similar input patterns, in the case of /k/ and /g/ because both are velar stop consonants differing only in terms of voice. Such sensitivity to similarities between sounds is demonstrated by the children in these experiments who are sensitive to the phonetic overlap between the cues and the target words which occurs at a featural level.

The finding that children are able to use phonological information in their very early reading development also has implications for our understanding about the size of phonological unit children of this age are able to access. Much research, reviewed in Chapter 1, has suggested that children are first able to access large units of phonology, for examples syllables or onset and rime units, and only later are able to access phoneme size units. The results of the cue learning tasks in this thesis, however, suggest that children are able to access and use information at a subphonemic level very early in their reading development. It has been suggested (Rack et al., 1994) that these differing findings on the size of unit accessed may be understood if a distinction is drawn between tasks which require the implicit use of phonology, such as the cue learning task, and tasks which are meta-cognitive in nature, such as phonological awareness tasks. It is possible that children are able implicitly to use smaller units of phonology in their learning than they are consciously aware of. The very nature of phonological awareness tasks requires a certain degree of meta-cognitive development whereas the implicit use of phonology in reading may rely on accessing underlying phonological representations which are already used in the child's spoken language. Some have argued that the role of conscious awareness of phonology in learning to read may have been over-emphasised. Hulme & Snowling (1992) suggest that it may not be the explicit awareness of phonology which is important but the quality of the underlying phonological representations themselves. According to this view phonological awareness tasks tap the phonological representations children are able to use implicitly in their reading development. This argument will be considered in more detail in section 7.2.2.

The findings discussed here suggest that rhyme is a less significant predictor of children's ability to learn to read words in the early stages of reading development. In all of the experiments it was phonemic awareness rather than rhyme awareness, which was related to word learning. This finding challenges the work of Goswami & Bryant (1990) and Bryant et al. (1990) which suggests that children's sensitivity to rhyme is the most important predictor of subsequent reading and that rhyme exerts a direct influence on reading by encouraging the use of analogy as an early reading strategy. However, there is also good evidence to suggest that children need some awareness of letter sound correspondences before they begin to use analogies (Muter et al., 1997; Ehri & Robbins, 1992). Furthermore, Duncan, Seymour and Hill (1997) found that even children with good rhyming skills were not disposed to using them when reading nonwords based either on the onset and rime of real words or on similar smaller units. They argue that young children identify words on the basis of smaller phonemic units more easily than on the basis of larger, rime, units. It is possible that although Goswami's work demonstrated a capacity for young children to use analogies in early reading development that this is not the unit they actually rely on in their early attempts at learning to read words. The present results certainly suggest a capacity to rely on smaller units in word learning. Furthermore, learning in all of the experiments was strongly predicted by phonemic, rather than rhyme awareness measures.

### 7.2.2 The Distinction between the Implicit and Explicit use of Phonology

The experiments in this thesis have examined both the implicit and explicit use of phonology by beginning readers. It has been argued that children implicitly access phonological representations when establishing associations between print and its pronunciation and explicitly use phonology when consciously reflecting on sounds in phonological awareness tasks. As discussed above, much research has emphasised the importance of explicit awareness but it has been suggested earlier that phonological awareness tasks tap underlying phonological representations which are implicitly used in spoken language. Arguably, it is the quality of these underlying representations which determines success or failure in reading. The fact that children in these experiments are able to access information they would not be explicitly aware of suggests that such a distinction is warranted. Experiment 1 examined the relationship between the implicit and explicit use of phonology in a cue learning task. The children were shown to be accessing phonology by the sensitivity they demonstrated to phonological information in the cue and its similarity to the target word; the children were also tested on a variety of phonological awareness tasks. Cue learning was found to be strongly related to, and predicted by measures of phonological awareness, particularly phonemic awareness. It is possible to suggest that one reason why children's sensitivity to the phonetic quality of the cues and their performance in phonological awareness task are so strongly related is that they both tap the same underlying phonological representations. It is also possible that the poor readers in Experiment 7 failed to learn as many cues and were less influenced by the phonetic quality of the cues than good readers because their underlying phonological representations were less well specified. This possibility is considered in more detail in Section 7.2.3.

### 7.2.3 The Role of Semantics

Most models of reading development to date have rather ignored the role of semantics in the very early stages of reading development, proposing that the acquisition and use of phonological skills is primary at this stage. Previous research has shown that children are able to use contextual facilitation to aid word recognition, however, these studies have tended to focus on children who already have a sight vocabulary and are able to read short passages. It would seem that beginning readers need first to achieve some level of context free word recognition before they are able to benefit from context. In terms of contextual facilitation, the role of semantics may be limited to a point in development when some level of phonological decoding skill has developed.

While it is clear that the development of phonological skills is crucial at this stage of reading development, the results of experiments in this thesis also suggest that semantic factors may play a part in the very early stages of reading development. In Experiment 1 the ability to learn to associate the cues with the target words was found to be strongly related to children's knowledge of the meanings of words. Indeed their ability to define the target words predicted their cue learning, even after measures of phonological skill had been controlled for. Experiments 4 and 6 also suggest a strong relationship between word knowledge and word learning. It is clear that children will have difficulty learning to read words that they do not know the meaning of. Although later in development children with good decoding skills may be able to read words they do not understand, these results suggest that not knowing the meaning of a word will certainly impede children's ability to learn to recognise it.

Other measures of semantic skill were also found to be strongly related to the ability to learn to read novel items. While the ability to define the specific words in the experiments was shown to be important, there is also some evidence that more general measures of vocabulary skill are related to word learning. Verbal analogy skills and performance in a semantic production task were found to be related to word learning in Experiments 2 and 6 respectively. However, these measures did not account for any variance in word learning once measures of phonological skill had been taken into account. Performance on a standardised vocabulary test was strongly correlated with word learning in Experiments 2 and 6. Evidence from

Experiment 4 suggests that the ability to define the actual words to be learnt is more important than general vocabulary skills, however, this was not found to be the case in Experiment 5. Part of the reason for this inconsistency lies in the difficulty of measuring vocabulary at this stage. Asking young children to define words is fraught with difficulties; it is a very difficult task for them and it is difficult to score. As a result the 'definitions' measures collected cannot be viewed as more than a rough approximation of their knowledge and this inaccuracy may account for some of the differing findings. Nevertheless, it can be concluded that semantic skills are related to word learning in this early stage of reading development. It is clear that further research needs to be done in order to examine the relationship between semantic skills and reading development more systematically.

A second way in which semantic factors were shown to be important in the very early stages of reading development is that the semantic quality of the individual words influenced the ease with which they were learnt. The semantic variable imageability has been shown to influence word recognition (Strain, Patterson, & Seidenberg, 1995) and comprehension (Schwanenflugel & Shoben, 1983) in skilled adult readers. There is some evidence to suggest that imageability may affect the ability of beginning readers to learn to read words (Richmond & McNinch, 1977; Yore & Ollila, 1985). However, these studies only included a very small number of items and there are other factors which may have explained the influence of imageability. McFalls, Shwanenflugel, & Stahl (1996) have criticised these studies for not controlling for grammatical class: the high-imageability words tended always to be nouns whereas the low-imageability words were adjectives and verbs. It is therefore possible that any advantage seen for the high-imageability words may have been due to differences in grammatical class and not imageability. It has also been argued that imageability may be confounded with age of acquisition and that when age of acquisition is controlled for imageability effects disappear (Coltheart, Laxon, & Keating, 1988).

Experiment 2 of this thesis examined the influence of imageability on early word learning controlling for age of acquisition and familiarity. The experiment found that the imageability of a word strongly influenced the ease with which children learnt to read it; high-imageability words were learnt more easily than low-imageability words. The word groups in Experiment 2 still differed in their grammatical class however, with most of the high-imageability words being nouns and most of low-imageability words being verbs and adjectives. In Experiment 3, therefore, it was thought necessary to control for grammatical class. In this experiment all the words the children were taught had a predominant verb sense. The influence of imageability on word learning was still found to be very strong. It is clear from these results that even children at the very early stages of reading development are influenced by the semantic quality of the words they learn to read even when age of acquisition and grammatical class are controlled for.

Strong imageability effects were also found in Experiments 6 and 7. In these experiments the interaction between phonological and semantic factors in early reading development was examined. The children were required to learn to associate three letter cues with target words, using the same paradigm as Experiment 1. However, in these experiments the target words also differed in imageability. The children in Experiments 6 and 7 were strongly influenced by the phonological and semantic quality of the cues they were learning. However, the influence of phonological and semantic factors appeared to be independent of one another, no interaction was observed. However, when good and poor beginning readers were considered separately they appeared to be differentially affected by the phonological and semantic quality of the words they were learning. In these experiments poor beginning readers were shown to be more influenced by imageability than good beginning readers. Conversely, the good beginning readers were more influenced by the phonological quality of the cue than the poor beginning readers. This finding suggests an interaction between the roles of phonological and semantic factors in early word learning, such that children with poor phonological skills will be more likely to rely on the semantic quality of the words they learn to read, whereas those with good phonological skills will be more likely to rely on the phonological properties of the words they learn.

The comparison of good and poor readers in Experiments 6 and 7 are somewhat limited in that they do not include control groups for the poor readers of younger children reading at the same level. As a result the finding that the poor readers were more influenced by imageability than the good readers may be due to the poor readers processing language in a qualitatively different way from 'normal' readers or to the fact that their processing is delayed. Nevertheless, the results allow some speculations to be made. There is some evidence from other studies that good and poor readers may be influenced differently by semantic factors such as imageability (Byrne & Shea, 1979) and this would appear to fit with the model proposed here, i.e. that impairments in either the phonological or the semantic pathway may be compensated for by the other, intact pathway (Nation & Snowling, 1998). Clearly this process would provide a mechanism by which those with dyslexia could compensate for their reading difficulties. It is interesting to note that if such a compensatory process does operate the present findings suggest that it would appear to happen from the very early stages of reading development. A second interesting finding from the comparison of good and poor readers is in terms of the rate at which they were able to learn to associate the cues with the target words. Again, the findings are limited by the lack of any reading age control groups, nevertheless, it was clearly the case that poor readers found it significantly more difficult to learn these cues. There is good evidence to suggest that older, dyslexic children show impaired phonological learning, that is they have considerable difficulties in paired associate learning tasks in which they are required to learn to associate a phonological with a visual or 'word-like' stimuli (Vellutino et al., 1975, Vellutino et al., 1995). Ehri & Saltmarsh (1995) found that dyslexic children took significantly more trials to learn to associate cues (abbreviated words) with spoken target words than reading age matched controls, furthermore, the representations of the cues that they learnt were shown to be incomplete. Ehri & Saltmarsh conclude that the dyslexic readers in their study have faulty word learning processes that impair the quality of lexical representations stored in memory. Problems with phonological learning may result from deficiencies in the underlying phonological representations or from difficulties in the process of linking visual and phonological information. The results of Experiment 7 suggest that this difference in word learning skill may also be present from the early stages of reading development. Clearly, if word learning is impaired in this way associations between orthography and phonology may be inadequately reinforced. The possibility that word learning is impaired and the relationship between phonological learning and other phonological skills is something that deserves greater attention in future studies.

Most models of reading development have tended to down play the role of semantics in early reading development. It is clear that in the case of contextual facilitation, children must first be able to read a certain amount before semantics can be said to have any influence on reading. However, the present experiments show that semantic factors play a role right from the start of reading development, even in single word learning. Plaut et al. (1996) propose an interaction between a semantic and a phonological pathway in their connectionist model of word recognition and suggest that a 'division of labour' occurs between these to two pathways. They argue that as learning continues a division of labour between the phonological and semantic pathway occurs; as the contribution from the semantic pathway increases the pressure to continue to learn using the phonological pathway lessens as some word types, in particular exception words, are more economically processed via the semantic pathway. The phonological pathway becomes increasingly specialised in pronouncing consistent spelling sound correspondences. This leads to the prediction that the semantic quality of some words will be more important than other words, for example, the influence of semantics would be expected to be greatest when phonological translation was most difficult, i.e. with low-frequency exception words. This pattern of results has been found in studies of adult word recognition (Strain et al., 1995).

The results presented in this thesis are not entirely consistent with the Plaut et al. model. In these studies semantic factors were seen to influence word learning much earlier than would be predicted by this model. According to Plaut et al. in the learning phase the semantic pathway does not have a role to play, however, the results of this thesis suggest that this is not the case and that semantic information may be used in reading from the outset. Furthermore, no interaction between phonological and semantic factors, as would be predicted by the Plaut et al. model, was found in these studies. Imageability was not found to influence the learning of the less phonetic 'control cues' more than the learning of the 'phonetic cues'.

There are a number of possible reasons while the present findings differ from the Plaut et al. model in this regard. Firstly, the Plaut et al. model is a model of adult word recognition rather than of learning, it is possible that the processes involved in these two tasks are different. Secondly, it is possible that the small effect sizes in the experiments presented here make such interactions statistically unlikely. Finally, it could be that there are developmental reasons why no such interaction was found. It is proposed by the Plaut et al. model that semantics will be seen to have an effect when orthographic to phonological translation is most difficult; in skilled adult reading this would be the case with low frequency exception words, however, with young children orthographic to phonological translation is always difficult because of the level of their reading development. It could be that in this early stage of reading development partial activations of both phonological and semantic units contribute to reading, however, with development, the pathways will become increasingly specialised and the influence of semantics will be seen only in certain situations.

It is not immediately clear from these experiments why imageability should influence children's performance in word learning tasks. As reviewed in Chapter 1, a number of possible explanations of imageability effects have been offered. It has been suggested that high and low-imageability words differ in their number of semantic features (Jones, 1985; Plaut & Shallice, 1993) and the greater number of features activated for high-imageability words explains their processing advantage. Imageability effects have also been accounted for by suggesting that imageable words contain a richer base of contextual information while low-imageability words rely on the context in which they occur for their meaning (Schwanenflugel, 1991).

Imageability effects have also been explained by effects of age of acquisition (Coltheart et al., 1988). Finally it is proposed that the meanings of high and low-imageability words are represented in qualitatively distinct ways (Paivio, 1986). An important question then is the extent to which the data presented here is able to distinguish between these different theories.

All of the imageability effects seen in these experiments have been found when age of acquisition is controlled for. This suggests that imageability exerts an effect on word learning independent from any effects of age of acquisition. This would appear to rule out age of acquisition as a sufficient explanation of imageability effects. However, Coltheart et al. (1988) did find some developmental and individual differences in comparing the effects of imageability and age of acquisition on word recognition. They found that younger, poorer readers were influenced by imageability when reading, even when age of acquisition was controlled for, but with older readers the imageability effect disappeared although the effect of age of acquisition remained. Is it possible that the children in these present studies would continue to be influenced by imageability with development, or could it be that age of acquisition is an important influence after all ? Clearly, these data do not allow firm conclusions to be drawn as only very young children were studied. However, as the effects in the Coltheart et al. study were not significant across items as well as subjects and the study was investigating speeded word recognition rather than word learning, perhaps no comparison between these studies should be made. At the very least it can be said that in the studies presented here children in the very early stages of reading development are influenced by the imageability of the words they learn to read even when age of acquisition is controlled for.

The experiments in this thesis have not really addressed the question of whether imageability effects are due to differing contextual dependencies of high and low-imageability words. Schwanenflugel (1991) argues that high-imageability words are processed more easily because they 'contain' more associated contextual information, for example, people find it easier to think of a sentence for such words. According to Schwanenflugel sensory knowledge does not have a special status in lexical processing but is just another example of prior knowledge. It is the relative access of this prior knowledge which predicts effects. It has been found that once context availability ratings are controlled for imageability will no longer influence lexical processing (McFalls et al., 1996). No context availability ratings were taken in these experiments and therefore it is not possible to rule this out as explanation of the imageability effects seen . Schwanenflugel & Akin (1994) suggest that the influence of these variables differs with development. In a lexical decision task young children were shown to be influenced by imageability while older children were no longer influenced by imageability but continued to be influenced by rated context availability. However, this is an unimportant finding with regard to the general conclusions of this thesis. Firstly, even Schwanenflugel and colleagues have found that young children are influenced by imageability and the children in the studies in this thesis are all young. Secondly, because the main conclusion is that semantic factors influence word learning at this stage and as both imageability and effects of 'context availability' are semantic variables the conclusion remains the same. Clearly however, the special role of sensory information in imageability and the ways in which this role may change with development are important theoretical questions.

The possible influences of age of acquisition and context availability in addition to those of imageability can be considered within connectionist models. In connectionist models such as that proposed by Plaut & Shallice (1993) and McRae et al. (1997) word meanings are represented in terms of semantic features. According to such models, high-imageability words have an advantage over low-imageability words in terms of the number of features they possess, accordingly in processing high-imageability words a larger number of features are activated and the correlations between features may be more dense than when low-imageability words are processed. It is possible that both effects of age of acquisition and contextual availability may simply have more features and therefore be processed with greater ease. Clearly, however, this does not answer the question of why high-imageability words should have more features.

One possible answer to this question lies in the dual coding approach proposed by Paivio (1971, 1986). According to Paivio lexical processes may be functionally distinct for concrete and abstract words. Dual coding theory proposes that two partly connected but functionally independent and distinct representational systems exist in memory: a verbal system and an image system. These systems are composed of smaller units called logogens in the verbal system and imagens in the visual system. It is suggested that one system triggers activity in the other. According to Paivio the arousal of images by high-imageability words causes a 'crossover' from the verbal to the imaginal system. In this model concrete words have more direct connections with referent imagens than do abstract words and it is this which gives concrete words their processing advantage. In this conception of semantic representation the role of imagery and sensory information is crucial.

To what extent does Paivio's model of semantic representation relate to the connectionist models under discussion here ? There are some important distinctions between the models. Firstly, a distinction should be made between the nature of representations in the models. In Paivio's model representation is in terms of logogen and imagen units, these are not well specified but would appear to relate to single lexical items in the case of the visual system, although may be made up of smaller letter and syllable units in the verbal system. In contrast in connectionist models no single perceptual unit uniquely encodes a single word or even a single phoneme, information is encoded in terms of a pattern of activation across featural units; therefore, representation is the same in both the phonological and semantic pathways, i.e., in terms of distributed, featural units. Secondly, in Paivio's model the role of imagery is central whereas it is not necessary in connectionist models which represent semantics in terms of features. According to Paivio concrete words have an advantage in accessing both a verbal and a visual system. In connectionist models it is because concrete words have a larger number of features.

Despite these differences some aspects of dual-coding theory could be incorporated within connectionist models. It is possible that concreteness is a function of the number of features but that the properties of these features differ. For example, it is possible to have different types of semantic feature, e.g. perceptual, functional and sensory. These features may even be stored in different areas of the brain. It is also possible that these different features differ in their status or in the density of the inter-correlations between them. Indeed it has been shown that by damaging certain types of features, or the connections between units, that patterns of difficulty mimicking those found in neurological patients are seen (McRae et al., 1997). It would seem that although there are some important differences between the dual-coding theory and connectionist models there may be some common ground. Although the data presented here do not allow judgements about the relative merits of these theories to be made, it is clear that further research could to some extent settle the matter. In particular it is important to consider the exact role of imagery in word recognition and the extent to which the visual and verbal systems are distinct as proposed by Paivio. As connectionist models have been successful in producing human like behaviour in terms of both normal and impaired subjects it would seem that representing semantics in terms of features has benefits and that representing information in terms of single lexical items is unnecessary.

In summary, the experiments in this thesis have shown that children in the early stages of reading development find it easier to learn to read high-imageability words than low-imageability words. By controlling for age of acquisition and differences in grammatical class it has been possible to rule these variables out as explanations for this advantage of highly imageable words. However, the data do not allow any conclusions to be drawn with regard to comparing dual coding and connectionist theories. It would seem that children learn high-imageability words more easily because they are 'richer' in some sense, although the exact reason for this richness is not clear from these data. However, the general conclusion remains, that even very young readers are influenced by the semantic richness of the words they learn to read.

## 7.3 Implications

### 7.3.1 Towards a Model of Reading Development

Many of the results presented in this thesis have important implications for models of reading development and suggest a number of ways in which current models may be improved in order to extend our understanding of the processes involved in learning to read.

Firstly, the experiments of this thesis provide no clear evidence that early reading is characterised by the use of a whole word or 'logographic' strategy which is used until children 'crack the alphabetic code' and begin letter-sound decoding. The findings suggest that children are able to use some partial letter-sound knowledge as soon as they have acquired it and don't need to await the development of decoding skills before they can use it. To this extent the results presented here support the view of early reading proposed by Ehri (1987, 1992) and Rack et al. (1994) which suggests that children in the very early stages of reading development form associations between partial letter-sound information in the word and the word's pronunciation. These associations are not the result of systematic left to right decoding but the use of one or two salient letters in the printed word. It is argued that children are able to infer sub-lexical relationships between letters and sounds from the outset. In this sense learning to read should be viewed as a continuum in which the same processes operate from the outset. According to this view children do not develop a separate alphabetic decoding strategy but simply, with increased exposure to print, their representations of letter sound relationships become more thorough and they become more systematic in their application of this knowledge. As suggested in previous sections, this approach is consistent with the approach espoused in connectionist models of reading development in which a single mechanism learns the statistical relationship between orthography and phonology. A model such as this would predict that children are sensitive to the phonological quality of the words they learn to read from an early stage. This was found to be the case in these experiments. Furthermore, it was hypothesised that the quality of the consonants in words would be of particular importance because they are more consistently represented. This was found to be the case, beginning readers found it more difficult to learn to read words containing irregular consonants than words containing regular consonants.

Ehri (1995) suggests that some form of logographic stage still exists, which she refers to as a pre-alphabetic stage. There is some evidence that very young children are capable of learning this way. Masonheimer et al. (1984) examined children's ability to read 'environmental print' such as the PEPSI sign and found that children did not notice letter changes in print, suggesting their 'reading' was purely visual. In one sense this does suggest a very early stage of reading in which children may learn without reference to letter sounds. This pre-alphabetic stage is similar to the logographic stage proposed by Frith (1985). The data presented in this thesis do not disprove the existence of such a stage, however, the results do show is that as soon as children have some letter knowledge they will use this to learn to read words. This is different from the model suggested by Frith (1985) which suggests distinct stages of reading development exist and that phonological information is not important until it is used explicitly and sytematically in the 'alphabetic stage'. The data presented here suggests that phonological information is used from the outset and certainly before the use of a systematic decoding strategy.

According to Ehri's (1995) model of reading development children progress from phonetic cue reading to 'full alphabetic' and 'consolidated alphabetic' reading. In these phases children form more complete connections between orthography and phonology. In the full alphabetic phase this allows for the successful reading of novel words. In the 'consolidated' phase letter patterns that recur across different words become consolidated allowing children to process multi-letter units such as syllables, onsets and rimes. These developments would also fit with connectionist models in that they also propose that a single mechanism is available from the outset of reading development and that with experience connections between orthographic and phonological units become more complete. In connectionist models this happens purely with increased exposure, however, Ehri suggests that an important factor in bringing about these changes is spelling instruction. Ehri & Wilce (1987) found that spelling training promoted reading skills in beginning readers not because it promoted better sounding out or blending skills (there was no difference between the experimental and control groups in this regard) but by promoting phonemic segmentation and by helping readers to store words in memory using letter-sound associations. Although the data presented here do not address the role of spelling, the strong relationship found between measures of phonemic awareness and sensitivity to the phonetic cues provides support for the idea that phonemic segmentation skills have an important role to play in early reading development.

The results presented here show that phonological awareness, in particular phonemic awareness, is an important predictor of the ability to learn to read words. While the relationship between phonological awareness and reading has been demonstrated many times before it has usually been done by examining correlates of reading skill and performance in phonological awareness tasks. In this thesis the link between phonological awareness and the rate at which beginning readers are able to learn to read novel items has been demonstrated. Children with good phonological skills were shown to learn to read more words, more quickly than children with less good phonological skills. One way of conceptualising the relationship between learning to read and phonological awareness is by suggesting that performance in phonological awareness tasks reflects the quality of phonological representations of a child and that it is these phonological representations which are used to set up associations between print and its spoken form. The fact that the children in these experiments were able to access much smaller units of phonology in their word learning than they were explicitly aware of in phonological awareness tasks supports the need for a distinction between the implicit and explicit use of phonology and suggests that the former is more central to reading development than the latter.

These findings have important implications for the size of phonological unit children are able to access and use in their early reading development. An important current debate is the relative influence of small and large units of phonology used in early reading development. The results presented here provide support for small unit theories. It has been shown that children are sensitive to phonological information at a subphonemic level in early reading development, beginning readers were shown to be sensitive to the degree of featural overlap between phonemes in the cue learning task. This finding fits well with connectionist models in which phonological information is represented in terms of featurally based distributed representations. This finding also suggests that theories which argue that children rely on large units such as syllable or rime units in their early word units may be wrong. Furthermore, children's ability to learn to read the words in these experiments is shown to be more strongly related to an awareness of phonemes than to an awareness of larger units such as syllables or rimes.

A further finding which has implications for models of reading development is the finding that semantics exerts an influence on early word learning. As discussed above, the models of reading development proposed to date have not considered the role of semantic factors in early reading development. However, the results of these experiments suggest that both the children's knowledge of the meanings of the words they are learning, and the imageability or concreteness of the words themselves, influences the ease with which children learn to read them. As suggested above this finding does not fit into the connectionist models of reading development in the same way as the other findings have. Plaut et al. (1996) consider the role of semantics in word recognition and argue that during the learning phase semantic factors are not important; the establishment of connections between orthography and phonology is considered to be primary at this stage. While the establishment of these connections is very important, and certainly determines the ease with which words are learnt, semantic factors have also been shown to be important. It is suggested that the role of semantic factors may be considered as a second form of direct mapping working in parallel with the processes involved in mapping phonology onto orthography. When children in the early stages of reading development are learning to read a new word their knowledge of some letter sounds enables activation at a phonological level, simultaneously semantic representations are activated, contributing to the correct recognition of the word. The semantic information may act to consolidate or reinforce the partial phonological information, with further exposure the connections become more complete and less 'back up' from the semantic pathway is required. In this sense semantic factors may provide a self-teaching mechanism in the early stages of reading development.

The experiments in this thesis suggest that phonological and semantic factors make independent contributions to early word learning. Considered within a connectionist framework it is possible to suggest that partial activations across both phonological and semantic units are important in early word learning. Given that the phonological and semantic pathways of beginning readers are not fully developed it is possible that partial information from each of these pathways is used to aid recognition. In setting up the initial connections between print and its pronunciation when learning to read novel items children may use any information they can in their word learning, this information may be phonological, visual, contextual or semantic in nature. In terms of a developmental model, therefore, it is possible to predict that as children's letter knowledge increases and becomes more systematic they will be less influenced by the semantic quality of words when learning to read them. However, it is possible, as Plaut et al. suggest, that the role of the semantic pathway will become increasingly specialised in aiding the recognition of words in which orthographic to phonological translation is difficult. In this way an interaction between phonological and semantic factors will begin to emerge.

In summary, the results presented here are consistent with many aspects of Ehri's model of reading development. The children studied here can clearly be said to be engaging in 'phonetic cue reading'. The results suggest that as soon as children have some letter-sound knowledge they will use this to form connections between print and its spoken form, even before they have acquired phonological decoding skills. It is suggested that reading does not develop as a result of changes in processing strategy used but rather that the same mechanism is used from the outset of learning to read, this is consistent with connectionist models (Seidenberg & McClelland, 1989). It was also found that children's ability to engage in phonetic cue reading was strongly related to their performance in phonological awareness tasks. Although the relationship between correlates of reading skill and performance in such tasks has been demonstrated many times before, the relationship is examined here in a more constrained experimental situation. An important way in which these results differ from the above models of reading development is in demonstrating the role of semantic factors in early reading development. It has been shown here that these phonological and semantic factors make independent contributions to word learning at this stage.

### 7.3.2 Suggestions for Future Research

As suggested above an important issue is how the relative role of phonological and semantic factors influence the process of learning to read at different stages of development. It is possible that this could be considered in future research. The same cue learning paradigm could be used with children of different ages in order to assess whether their reliance on phonological and semantic factors changes as they get older. One prediction would be that as their letter knowledge and phonological skills improve they will be less influenced by word imageability. Such a developmental approach may be able to identify the point in development when the semantic pathway begins to interact with the phonological pathway in order to support the recognition, and possibly learning, of exception words. It is possible that the influence of imageability will continue for children with reading difficulties. The results of this thesis suggest that poor beginning readers are more influenced by imageability than good beginning readers in learning to read words. However, it is not clear from this study whether this reliance on the semantic quality of the word reflects the different processing of poor readers or processing which is commensurate with their level of reading ability. That is, it is possible that the poor readers examined here are learning no differently from younger children at the same reading level. An important improvement, therefore, would be to investigate the word learning of older children with a specific reading disability and to compare it with the learning of reading age as well as chronological age matched children.

It has been proposed in this thesis that children in the very early stages of reading development are particularly affected by the regularity of the words they learn to read when the irregularity is found in the consonants of the word. One suggestion for future research would be to compare vowel and consonant regularity more systematically. It is important to rule out the possibility that differences found in the experiments in this thesis may be due to different words used rather than the type of irregularity included. In order to examine this in more detail the learning of words containing irregular consonants and the learning of words containing irregular vowels should be compared directly.

Two suggestions might be made with regard to further examining the influence of imageability on word learning. Firstly, the reasons imageability influences learning could be examined in more detail. An important limitation of these studies is that they do not control for rated context availability and therefore although the limitations of this theory have been discussed, it cannot be ruled out as an explanation. Secondly, there is a need for more modelling work which could include an examination of the early effects of imageability found in these experiments.

Finally, some of the semantic measures used in this thesis have proved to be strong predictors of the ability to learn to read novel items, while others have been less strong predictors. Furthermore, some tests have been reliable in one experiment but not in another, the results are therefore somewhat inconsistent in this regard. It is important that the accurate measurement of children's semantic representations of words at this stage is achieved in order to further examine the relationship between these representations of words and the ease with which children learn to read them. Asking children of this age to provide definitions of words is fraught with difficulties, it is possible that the use of a picture vocabulary test would have given a more accurate measures of their knowledge of the meanings of words. Furthermore, it should be possible to provide a more subtle measure of the quality of children's semantic representations of words, that is, a measure of the extent to which children know the meanings of words.

### 7.3.3 Educational Implications

It is important to consider the implications of this research for the teaching of reading. One important finding throughout this thesis has been that children are sensitive to phonological information from the very earliest stages of reading development. This suggests that a teaching approach which encourages children to develop their phonological skills and to relate this information to their learning will be most successful. It would seem to be important that letter-sound patterns and similarities between letter patterns in different words should be pointed out from the start of learning to read rather than teachers encouraging a whole word strategy by an overemphasis on the visual features of words.

These experiments demonstrate that children are able to infer a great deal of information about a word's pronunciation for themselves, indeed research has shown that even beginning readers are able to infer sublexical information from words and apply it to the learning of novel items (Thompson, Cottrell, & Fletcher-Flinn, 1996). However, this does not mean that children will, in effect, learn to read without instruction. One important implication of these findings is the need for children to learn letter-sound relations as early as possible in the process of learning to read in order that they may begin to use this knowledge to form connections between print and its spoken form. The findings discussed here do not support a teaching strategy based on encouraging children to make analogies between words on the basis of rime units, as is suggested by the work of Goswami (1986, 1988). However, it is possible that encouraging the use of analogies could be an effective strategy if based on smaller units, for example on the basis of shared letters. The results of this thesis suggest that explicitly encouraging children to focus on the letter similarities between different words may encourage them to use this information in learning to read words not previously encountered.

Given the role of semantics discussed in this thesis it is important that educational practice includes an emphasis on semantic skills. It was found that children found it very difficult to learn to read words they did not know the meaning of. This suggests that developing good vocabulary skills from an early stage might have a very positive effect on the development of reading skills; this must include the specific teaching of more abstract words which children seem to find particularly difficult to learn to read.

The research presented in this thesis has examined the processes involved in children's early attempts at learning to read words. It was shown that these attempts are not characterised by the use of a visual strategy but that as soon as young children know some letter sound relationships they will use this information to form associations between print and its spoken form, and hence learn to read the word. Evidence was also presented which suggested that children's semantic representation of words influences the ease with which they will learn to read them. Future research should aim to further examine the interaction of these two factors on children's reading from a developmental perspective. This would allow, not only the improvement of theoretical models of how children learn to read, but would also suggest the best way in which these skills could be integrated into a successful teaching strategy.

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