

CHILDREN'S USE OF ANALOGY IN READING AND SPELLING

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St. John's College

A thesis submitted for the degree of Doctor of Philosophy
in the University of Oxford, Trinity Term, 1986.



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Abstract

This thesis examines the role of analogy in the development of reading and spelling. Analogy is defined as using the spelling-sound pattern of one word (e.g. 'beak') to read or spell a word which shares a common orthographic sequence (e.g. 'bean' or 'peak').

Experiment 1 shows that 6-7 year old children can use analogies when required to select the correct spellings of words which are read to them. Experiment 2 shows that children aged 5-7 years can also use analogies to read new words aloud. Experiment 3 shows that analogy is used in the same way by children at three different reading levels (non-readers, 6 years and 7 years). Experiment 4 shows that 5-7 year old children can also use analogies to spell new words. It is concluded that the use of analogy does not develop, as it is available from the very beginning of learning to read and spell.

Experiments 5, 6 and 7 examine the effect of varying spelling-sound consistency on analogies. Children taught pairs of words consistent in spelling and sound (e.g. 'peak-leak') make more analogies in reading than children taught pairs of words consistent in spelling but inconsistent in sound (e.g. 'peak-steak'). This difference does not occur in spelling. It is concluded that spelling-sound consistency only affects children's use of analogies in reading.

Experiment 8 shows that children also use analogies to read new words which they encounter in reading prose. This shows that analogy is not restricted to single word reading. Experiment 9 compares analogies between words written in the same case and in mixed case. It shows that analogy relies on orthographic rather than visual information.

These results suggest that children should be taught to use analogies to read and spell new words. The broader educational implications of analogy are also discussed.

Note. This thesis contains approximately 91,000 words.

Acknowledgements

My first and most important acknowledgement is to my supervisor, Peter Bryant, whose help and enthusiasm has been invaluable. He has been a wonderful supervisor, and this work would have been impossible without him.

Secondly, I would like to thank Dr. Robert Hiorns and Dr. Yiannis Vlachonikolis for very helpful statistical advice. I also thank Dr. David Porter, Dr. Susan Somerville, and other members of the Psychology Department for statistical help. Special thanks are due to Jerry Broad and Anita Butterworth for preparing all my experimental stimuli.

I would also like to thank all the staff and especially the pupils of the schools in Oxford in which this research was conducted. Their help and interest was greatly appreciated.

Finally I would like to say a big thank-you to my family, and to all my friends, who have been a real help and support (especially Karen and Hugh Possingham, Dale Tiller, Prajna Das-Gupta, David Neilson and Gaby Guz).

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ABSTRACT

This thesis examines children's use of analogies between the spelling patterns in words as a strategy for reading and spelling new words in English. Analogy is defined as using the spelling-sound pattern of one word (e.g. 'beak') to read or spell a word which shares a common orthographic sequence (e.g. 'bean' or 'peak'). The main question of interest is whether young children in the earliest stages of learning to read and spell can use such an analogy strategy, or whether analogy is a relatively sophisticated type of reasoning which is not available until later in development. Additional questions are the role played by analogy in learning to read and spell, and the effects of ambiguity in written English (such as variations in spelling-sound consistency) on children's willingness to use orthographic analogies.

In Chapter 1, the questions to be examined in this thesis are set out. It is suggested that current theories of reading development (visual-orthographic and phonological) are insufficient on their own to explain how reading develops, and that an additional strategy is required, namely analogy. The use of an analogy strategy to read and spell new words would enable children to use their current reading and spelling knowledge to make predictions about new words, and would also enable the decoding of many so-called 'irregular' words, which are quite consistent once larger spelling units are taken into account (e.g. 'light', 'fight', 'night'). Analogy in reading and spelling is then defined, and the additional component skills required to make analogies in written language, such as categorisation and segmentation, are discussed.

In Chapter 2, the cognitive-developmental literature on analogical reasoning is reviewed. It is shown that most of the work

conducted on children's analogical reasoning abilities has concluded that analogy is a form of reasoning which only emerges with the onset of the Piagetian period of formal operations in early adolescence. However, it is claimed that this conclusion is based partly on a misunderstanding of Piaget's theory concerning the link between analogical reasoning and proportionality, and partly on poorly-designed experiments which rely largely on multiple-choice verbal analogy problems. In the final section of Chapter 2 (section 6), some recent work on children's use of analogical reasoning in concrete situations is presented, which suggests that children as young as 4 and 5 years of age can reason analogically. It is concluded that there is no reason to believe that children in the early stages of reading and spelling development do not have an analogy strategy available.

In Chapter 3, the few experiments which have been done on children's use of analogies in reading and spelling are discussed. Two major claims are identified. One is that analogy is a developmentally sophisticated strategy available only in the final stage of learning to read and to spell, made by Marsh and his co-workers. The other (Baron 1977) is that analogy is a strategy which is used naturally even by kindergarteners to read new words. However, it is shown that the evidence on which both these claims are based is unconvincing, and it is concluded that further work is needed to decide between them. The final section of the chapter considers the link between orthographic analogies and the cognitive-developmental literature on analogical reasoning. It is concluded that orthographic analogies are true analogies, and thus that the cognitive-developmental literature should not be ignored by workers in the field of reading and spelling development.

Chapter 4 then reviews the literature on the component skills required to make orthographic analogies (categorisation, chunking, rhyming, segmentation, and blending), in order to determine whether children have such skills available before they begin to learn to read. This chapter is in 9 sections.

Section 1 introduces the issues to be examined. Section 2 shows that children have good categorisation skills from an early age, both visual and phonological, and also have strong expectations about the links between spelling and sound, expecting words which look similar to sound similar. Section 3 looks at evidence regarding children's ability to chunk words into the units required for analogies, and concludes that such chunking skills are available before reading begins. In section 4, children's rhyming skills are discussed, and it is shown that rhyming and alliteration skills are present before reading commences, and furthermore are important predictors of later reading and spelling ability. It is suggested that analogy may play a role in explaining this connection between early rhyming and later reading and spelling.

Section 5 examines the literature on children's segmentation skills, and concludes that some kinds of segmentation (e.g. phonemic segmentation) only emerge as reading develops. However, in section 6 it is shown that the kind of segmentation required for analogy is available before children learn to read. Section 7 discusses the evidence on children's blending skills, and concludes that blending is well-developed before reading commences. Finally, section 8 considers studies which look at blending and segmentation together, and it is suggested that while both skills are available before reading begins, learning to read enhances children's blending and

segmentation abilities. It is concluded in section 9 that all the component skills required to make orthographic analogies are precursors of reading.

Chapter 5 briefly reviews the adult literature on reading by analogy, as this has provided the main forum for debate about the importance of analogies in reading new words. The classic dual-route model of reading is first discussed, and then the challenge to this model posed by an analogical theory of skilled reading is demonstrated. The major experiments which support an analogical rather than a dual-route model are examined, and possible modifications to classic dual-route theory which can accommodate some of these results are also briefly mentioned. However, it is concluded that some of the experimental findings are impossible to explain even by such modified theories, and that analogy theory offers the most satisfactory model of skilled reading. The implications for theories of reading development are then examined, and it is concluded that empirical work is needed to investigate these implications.

The first experiment performed to investigate the development of the use of an analogy strategy in reading is presented in Chapter 6. Children aged from 6-7 years were asked to choose the spelling patterns of new words read to them by the experimenter from an array of possible spelling patterns which they were given, either when an analogous 'clue' word was present to help them, or in the absence of any clue word. Both readers and non-readers were tested. It was found that the children were significantly better at choosing the correct test words when they could use analogies between the spelling patterns at the beginnings of the clue and test words to help them. This showed that children can make orthographic analogies between the

spelling patterns in words when the pronunciation of the unknown words are provided.

The second experiment presented in Chapter 6 examined whether children could also use such analogies if the task was one of reading aloud. Children aged from 5-7 years were given clue words such as 'beak', and were asked to read new words aloud which were either analogous ('beak-bean', 'beak-peak') or non-analogous ('beak-bask', 'beak-rain') to the clue words. Again, both readers and non-readers were studied. It was found that both groups performed significantly better when analogies could be made between the ends of the clue and test words. This showed that children can use analogies between the spelling patterns at the ends of words to help in reading new words aloud.

In Chapter 7, a more detailed version of Experiment 2 is presented, in which the use of analogy by children reading at three different reading levels was compared for both real words and nonsense words. It was found that children reading at the 6 and 7 year old levels used analogies between both the beginnings and the ends of words to read new words aloud, for both real words and nonsense words, although both groups made significantly more analogies between the ends than between the beginnings of words. The non-readers only made analogies between the ends of words.

However, no other differences in the use of an analogy strategy were found. This was a striking result, as it suggested that analogy is available right from the beginning of learning to read, and that the ability to use analogies in reading does not develop. Experiment 3 further demonstrated that a significant relationship existed between rhyming skills and the use of analogies in reading, which

supports the idea that the use of analogies in reading is the link between early rhyming skill and later reading ability. It is concluded that the hypothesis that analogy is a sophisticated strategy characteristic of children in the final stage of reading development can no longer be maintained.

Chapter 8 examines whether children can also use an analogy strategy in spelling. In Experiment 4, children aged from 5-7 years were asked to spell both analogous and non-analogous words either in the presence of a clue word from which analogies could be made, or without such a clue word being provided. It was found that children spelled significantly more words correctly compared to Pretest only when analogies could be made from either the beginnings or the ends of the clue words. As in reading, significantly more analogies were made between the ends of words than between the beginnings of words. A significant relationship between rhyming and alliteration skill and the use of analogies in spelling was also found. It is concluded that analogy is used by young children to spell new words from the beginning of learning to spell, and may play a role in explaining the link between early skill in rhyming and later ability in spelling.

In Chapter 9, the effect of spelling-sound consistency on children's willingness to make analogies in reading and spelling is examined. In Experiment 5 (reading), children were taught pairs of words which varied in spelling-sound consistency, and the number of analogies which they made to new words was then assessed. The taught pairs were either consistent in spelling and sound (e.g. 'peak-leak'), consistent in spelling but inconsistent in sound (e.g. 'peak-steak'), or unconnected in spelling and sound (e.g. 'peak-loan'). The new words were either Analogous ('weak', 'beak'),

or Ambiguous (words which looked analogous to the taught pair but which were pronounced differently, e.g. 'break'). Using analogy to read the Ambiguous words can result in nonsense words (e.g. "breek"). It was found that children made most analogies to both wordtypes when they learned about consistency (peak-leak), fewer analogies when they learned unconnected pairs of words (peak-loan), and fewest analogies when they learned about inconsistency (peak-steak). It is concluded that even though inappropriate analogies in reading can be checked via the production of nonsense words, children make analogies in reading to both Analogous and Ambiguous words. However, for both these wordtypes, children's willingness to use analogy depends on the consistency of the spelling-sound patterns of the words which they have been taught.

Experiment 6 then examines the same question in spelling. Children were taught to spell pairs of words which varied in consistency as in Experiment 5, and the effect on their spelling of both Analogous and Ambiguous words was then assessed. The Ambiguous words used in Experiment 6 were words like 'meek' and 'seek', which sounded as though they should be analogous to the taught pair but were actually spelled differently. However, in spelling there is no cue to tell children that analogies to the Ambiguous words are inappropriate. The results showed that spelling-sound consistency had no effect on the number of analogies made in spelling, as there were no differences in the number of analogies made from the different taught pairs. It is concluded that spelling-sound consistency does not affect children's willingness to use analogies in spelling.

This unexpected result was checked further in Experiment 7, which is presented in Chapter 10. Here the children were taught to

read pairs of words which varied in consistency as in Experiment 5, and their spelling of new Analogous and Ambiguous words was then assessed. The aim of this experiment was to see whether children would use information gained through reading to modify their spelling of new words. It was again found that there were no differences in the number of analogies made from the different taught pairs. However, a significant number of analogies were made in all conditions. It is concluded that reading knowledge can be used to modify spelling behaviour, but that spelling-sound consistency does not affect children's willingness to make analogies in spelling.

In Chapter 11, children's use of analogies in a more natural reading situation is assessed, by examining the use of analogies in reading prose. In Experiment 8 children were given short stories to read. Some of the new words in the stories could be read by analogy to a clue word in the title of the story. It was found that children were significantly better at reading these words when they were taught the clue words in the story titles than when they were not. Furthermore, it was found that there were no differences in the number of analogies made to the beginnings and ends of words. It is concluded that analogy is an important strategy in prose reading, and that when reading prose analogies between the beginnings and the ends of words are equally important.

In Chapter 12, the processes underlying the use of analogies in reading are examined. In Experiment 9 children were given both analogous and non-analogous words to try and read by using clue words as in Experiments 2 and 3, but this time the test words were either written in the same letter case as the clue words, or were written in a mixture of different letter cases. In the Same Case condition, both

visual and orthographic information is present, but in the Mixed Case condition, only orthographic information can be used, as the visual appearance of the clue and test words is very different. It was found that children made as many analogies in the Same Case condition as in the Mixed Case condition. It is concluded that analogy is based on orthographic rather than on visual information.

Chapter 13 summarises the conclusions of this thesis, and assesses the implications for future work. The questions raised at the beginning of the thesis and the degree to which they have been answered are discussed, along with the limitations of the experimental studies conducted. More research on the development of orthographic knowledge is then encouraged, including investigations of the effect of the number of shared letters in words and of the position of shared letters in words on analogy. Research on the educational implications of analogy is also urged, both in the area of reading and spelling development and in wider cognitive-developmental terms, and some future experiments are suggested.

CHAPTER ONEINTRODUCTION1.1. Current theories of reading development: Are they sufficient?

The question of how children learn to read is still a controversial one. Two main strategies for learning words have been proposed by different authors, a visual-orthographic strategy and a phonological strategy. In a recent review of research on the development of word recognition, Barron (1986) calls these strategies the 'direct access hypothesis' and the 'indirect access hypothesis', respectively. This is because a visual-orthographic strategy is meant to allow direct access to the lexicon, while a phonological strategy can only achieve lexical access indirectly through sound. This thesis will argue that neither of these strategies is sufficient alone for learning new words, and that an additional strategy is required for reading development to occur, namely, analogy.

Children who rely on a visual/orthographic strategy to read aloud are said to depend on the visual appearance of whole words, visual shapes being associated with individual words or parts of words in lexical memory (Bryant and Bradley, 1980). These readers are characterised as "Chinese" by Baron and Strawson (1976), as their reading is comparable to an ideographic process. Baron and Strawson contrast these readers with "Phoenecians", or readers who rely on individual letter-sound correspondences in order to get sound from print. Phoenecians build up pronunciations for words by blending individual letter-sound correspondences together, and thus rely on phonological rather than visual strategies for reading aloud. Many authors prefer to see learning to read as a phonological process, as

children already have phonological representations of words from speaking and listening, and so a sounding-out strategy enables them to link written letter strings with phonological knowledge which they already possess (Rozin and Gleitman, 1977).

I wish to argue that the debate about whether early reading development is visual/orthographic or phonological in nature does not go far enough, as neither of these strategies is sufficient on its own to explain how children learn to read. Adoption of a 'Chinese' reading strategy would mean that every word must be learned individually, so that words such as 'light', 'fight' and 'might' would have to be learned as unique 'ideographs'. Adoption of a 'Phoenecian' reading strategy would also be insufficient for learning to read, as the pronunciations of irregular words such as 'light' and 'fight' cannot be derived by sounding them out letter-by-letter. The use of phonological strategies for reading irregular words would lead to mispronunciations which give no clue to meaning, such as "lig-hut" for 'light'.

1.2. An additional strategy: analogy

Clearly, some extra strategy other than a purely visual/orthographic or phonological strategy is required if reading development is to take place. The most likely candidate for the extra strategy is analogy. Use of analogy in reading would allow a child to make inferences about the sound of a written word from its spelling pattern, given that she knows other words which have the same spelling pattern. Thus a child who knew a word like 'light' should be able to work out the pronunciation of a new word like 'fight', as the shared similarity in spelling would provide grounds for making an analogy about sound. An analogy of this kind involves reasoning that

the similarity in spelling must predict a related similarity in pronunciation. For example, if the shared orthographic sequence is at the end of the words, as in 'light-fight', then the words must also sound similar at the ends - they will rhyme. In this thesis, I would like to consider the possible role of such analogical skills in early reading and spelling development. I will also consider whether rhyming skills have a special role in the use of orthographic analogies.

Analogical skills would seem to be very important for reading development on a priori grounds, since a child who could make an analogy from a known word to a new word in reading could use her current reading knowledge to make predictions about the pronunciation of new words, enabling rapid vocabulary expansion. A child who knew the pronunciation for the letter string 'light' would have a basis for predicting the pronunciation of other '-ight' words, such as 'fight', 'might' and 'right', without having to learn each word separately as a unique whole. Presumably, analogy could be extended to other words like 'high' and 'sigh', as the pronunciation of the letter sequence '-igh' can also be derived from 'light'.

In the same way, analogical skills should also be important for spelling development. A child who knows how to spell a word like 'light' should be able to work out how to spell a new word like 'night', as the shared similarity in sound (rhyme) provides a basis for making an analogy about spelling patterns. Thus spelling knowledge could be used to make predictions about the spelling patterns of new words which sound similar to known words.

It could be argued that analogy may be a less successful strategy to use in spelling than in reading, as many words which

sound similar are spelled differently (e.g. 'night', 'bite'; 'search', 'perch', 'birch', 'lurch'..). While the same is true to some extent in reading, with similar spelling not always indicating similar sound (e.g. 'beak-break'), it is less frequent. As stated by Hatfield and Patterson (1983) "...in general, there are far fewer phonological segments with predictable orthography than there are orthographic segments with consistent pronunciation" (p. 454). Furthermore, in reading the sound of a word can provide a check as to whether a given analogy is appropriate. Using 'beak' as a basis for making an analogy about the pronunciation of a word like 'break' results in a nonsense word ("breek"), which shows that the analogy is inappropriate. There is no such check in spelling. So analogy may not be as efficient a strategy for spelling as for reading new words.

Such analogical abilities have not been widely studied. However, studies by Marsh, Desberg and Cooper, (1977); Marsh, Friedman, Welch and Desberg, (1980a, 1980b); Marsh, Desberg, Friedman and Saterdahl, (1981); and by Baron, (1977, 1979) do investigate one kind of analogy that children may use, analogies based on rhyme (e.g. 'light' -> 'fight'). Their studies investigate the process of making analogies from known words to new words. The use of the term 'analogy' in this respect will now be elaborated.

1.3. Definitions of analogy

Marsh et al. (1977) define analogy as the "search for a familiar word by analogy to the known word(s)." (p. 391). By this, they appear to mean that known words can help in deciding the pronunciation of a familiar spoken word which has not previously been met in print. For example, the nonsense word 'tepherd' would be pronounced "tepard" by an analogy strategy (using 'shepherd' as the basis for analogy),

whereas pronunciation via single letter-sound correspondences would give the pronunciation "tefard". Similarly, the nonsense word 'cetto' would be pronounced one way by analogy to 'cello', and another by spelling-sound rules. While these examples are surprising given that nonsense words are by definition unfamiliar, it is clear that use of an analogy strategy involves using a word which has almost exactly the same spelling pattern as the target word to derive a pronunciation for the target word.

Baron (1979) is more explicit about the connection with rhyme. He states that "a person might use analogies by parsing the stimulus (e.g. 'yave' -> 'y' + '-ave'), searching memory for words with these parts (e.g. 'gave' or 'save'), and inferring the response to the stimulus from these analogies....Thus 'yave' and 'fliend' might be read by analogy to 'have' and 'friend'". (p. 61). Baron's examples make it clear that analogy involves the use of words which are similar in spelling to the target words apart from the initial consonant/s. As Baron says, this process must involve parsing or segmenting the stimulus word in order to form the analogy.

The involvement of segmentation suggests that reading or spelling new words by analogy to known words may require more than simply the ability to reason analogically. In fact, in order to make such analogies other component skills are also required, namely chunking, blending, and categorisation skills.

1.4. The component processes required for analogy

In order to use a known word to read a new word by analogy as defined by Baron, the child must first select a word with a similar spelling pattern to the target word, choosing one which differs only

in its initial consonant. This requires visual recognition and graphemic categorisation skills, as the child must be able to categorise words as being similar or different on the basis of their spelling patterns in order to select an appropriate match (e.g. 'gave' and 'yave').

Having chosen the analogical match, the child must then derive the correct phonology for the new word from the known word. To do this, the child must isolate the analogically relevant section of the word phonologically. This requires segmenting the known word into initial consonant(s) and vowel + terminal consonant(s), (i.e. into 'onset' and 'rime'), as in 'g + ave'. The pronunciation of 'gave' will only help in pronouncing 'yave' if it is segmented into /g/ + /ev/, as only the analogous segment /ev/ is relevant to the pronunciation of 'yave'.

Such segmentation is not strictly parsing, as it must involve chunking skills: the child must distinguish which letters belong to the rime of the word, and chunk these together. Such chunking is quite complex, as can be seen in Baron's example 'fliend-friend'. Here the child must group together the letters '-iend' and separate them from the onset 'fl-'. A simple parsing strategy such as 'separate initial letter from the rest of the word', which would work for a word like 'yave', would lead to incorrect chunking in the case of 'fliend' (f + -liend). It is impossible to find an analogy for the chunk '-liend' in English, whereas analogies for the chunk '-iend', which forms the rime of the word, can be found (fiend, friend).

Thus chunking must involve phonological as well as graphemic knowledge, as the child has to be able to decide which letters of the written stimulus correspond to the phonological onset of the spoken

word. This is an especially difficult task for words with complex onsets, such as 'chess' and 'school', where more than one letter represents a single phoneme.

The definition of analogy as dependent on shared orthography between the ends of words further suggests that rhyming ability must play an important role in the use of analogies in reading. Orthographically similar pairs of words, such as 'yave-gave', 'fliend-friend', and 'tepherd-shepherd' not only share similar spelling patterns at the end, they also rhyme, and it is the rhyming part of the word which gives the analogous pronunciation. So the use of analogies in reading may depend crucially on rhyming skills.

Finally, to pronounce 'yave' the child must also find out how the letter 'y' is pronounced. This can either be accomplished by analogy to a different word, like 'yes', or by using single letter-sound correspondence knowledge ('y' -> /y/). Having found the pronunciation of the 'y', the child then needs to blend together /y/ and /ev/ to arrive at the pronunciation /yev/. Thus the apparently simple act of choosing an analogical word and using it to read a target word is actually quite a complex process, requiring the possession of categorisation, segmentation, chunking, rhyming and blending skills.

In order to use a known word to spell a new word by analogy, the same skills are required. The child must first select a word which sounds similar to the target word (e.g. 'light-fight'), involving the use of rhyme and categorisation. Next, the child must isolate the analogically relevant section of the word (/ait/), requiring segmentation and chunking skills. Finally, the child must blend together the spelling of the analogical section of the word ('-ight')

with the spelling of the onset of the word ('f'), the latter being derived from sound-spelling rules or further analogies. Again, it is clear that the use of analogy requires complex processing on the part of the child.

1.5. Overview

A number of issues must thus be considered in studying the role of analogy in early reading and spelling development. The first of these is the question of how good children are at analogical reasoning in general. This is a question which has been ignored by authors like Marsh and his colleagues, and by Baron, who have made claims about children's use of analogy in reading and spelling without taking into account the cognitive-developmental literature on analogical reasoning, even though this literature is relevant to the kinds of claims which can be made. To remedy this omission, work in the area of cognitive development on children's ability to reason analogically is reviewed in Chapter 2. Chapter 3 then reviews evidence for children's use of analogy in reading and spelling, and the relation between both types of analogy is assessed.

Secondly, a number of complementary component skills are required if analogies are to be made in reading and spelling. These are categorisation, segmentation, chunking, rhyming, and blending. In order to examine the role of analogy in early reading and spelling development, it must first be established that children have such skills available prior to learning to read and spell. Work on children's categorisation, chunking, rhyming, segmentation and blending skills is reviewed in Chapter 4. Finally, theories of reading by analogy, based on work with adults, are briefly reviewed in Chapter 5.

CHAPTER TWOANALOGICAL REASONING IN CHILDREN2.1. Introduction

An analogy is usually defined in the problem-solving literature by reference to Aristotle, as "an equality of proportions...involving at least 4 terms..when the second is related to the first as the fourth is to the third" (in Metaphysics). An example would be 'high is to low as wide is to narrow'. The standard representation of an analogy is ' $a:x::b:y$ ', i.e., 'the a term is related to the x term as the b term is related to the y term'. Furthermore, the representation is held to be a proportional one, which means that it must be possible to state it both as $a:x::b:y$, and as $a:b::x:y$.

Experimental work on analogical reasoning in children is limited. The early work was based on Piaget and Inhelder's (1958) study of logical reasoning, which led to the widespread belief that analogical reasoning required an understanding of proportional relations. As Piagetian theory suggests that an understanding of proportionality does not develop until adolescence, the early view taken of children's ability to reason by analogy was a rather pessimistic one. This early work mainly concentrated on the solution of verbal analogies, and will be reviewed first. Piaget's own experiments on analogical ability, carried out in 1977, will then be examined, and finally the information-processing approach to analogical reasoning, recently adopted by Sternberg and others, will be considered.

2.2. Piaget's early theory of logical reasoning: ratio and proportionality

The idea that analogical reasoning was closely connected with an understanding of proportionality was based on the experimental work of Piaget and Inhelder (1958), which suggested that an understanding of ratio and proportionality were not acquired before the stage of formal operations. This stage follows the concrete operational stage of thought, and is normally entered between the ages of 11 and 13:

"Concrete operations may be called first degree operations in that they refer to objects directly. For example, this is the case in the structuring of relations between given elements. But it is also possible to structure relations between relations, as for example in the case of proportions (our experiments show that proportions are not mastered before the formal level). In this sense, proportions presuppose second degree operations..." (p. 254).

Many authors (e.g. Lunzer, 1965; Sternberg and Nigro, 1980) have taken this statement as evidence that Piaget claims that the ability to reason analogically, which requires reasoning about the relations between relations, will not be acquired before the stage of formal operations is reached. However, it is not clear whether Piaget himself is making such a claim. Later in the same work, he refers further to the understanding of proportions, seeming to separate them from an understanding of analogy:

"Mathematical proportions consist simply of the equality of two ratios $x/y = x'/y'$. Their formulation raises a psychological problem only because it does not take place during the concrete operational stage. The subject at this level can already construct fractions...moreover...beginning with the concrete level, we see evidence of an operation that Spearman has called 'the eduction of correlates' in which the subject formulates the links in a double-entry table in such a way as to forecast proportions: for example, 'Rome is to Italy as Paris is to France'. This is why we wonder why the 8-11 year old subjects are not able to discover the equality of the two ratios which form a proportion..." (p. 314).

Hence Piaget seems to be taking a position far removed from the one attributed to him, namely that an understanding of proportionality must precede an understanding of analogy. Instead, he remarks that it is puzzling that concrete operational children can understand analogy and yet not understand proportionality.

2.3. Studies of analogy based on Piaget's assumed early theory

2.3.i. Studies of the link between proportionality and analogy

Many authors have adopted the position that an understanding of proportionality must precede an understanding of analogy. For example, Lunzer (1965) cites Piaget in support of his suggestion that analogical reasoning in children will not appear before the age of 12 years. Lunzer argued that, as analogical reasoning requires an understanding of proportionality, children's performance on verbal and spatial analogies can elucidate the nature of their problems with proportionality.

In accordance with this hypothesis, Lunzer tested boys aged from 9-17 years on different verbal and numerical analogies, designed to range from easy (level A) to difficult (level D). Examples from the verbal analogies are "Black is to white as hard is to steel/stone/solid/soft/blue" (level A), and "Leather is to soft/shoe/hide as hard/clay/house is to brick" (level D). Numerical analogies include 3:1, 9:7, 10:8, 4:?

5:125, 4:64, 2:8, 3:?

18:12, 10.5:7, 21:14, ?:6

These increase in difficulty, the relationships being respectively subtract 2, raise to the power of 3, and multiply by $\frac{2}{3}$. Lunzer's hypothesis was that the level A problems should be

possible for children who were still in the stage of concrete operations, while the harder problems would require formal operational reasoning and would only be solved by the older children.

The results showed that successful performance was only at around 30% for the 9 year olds, even on the easiest verbal problems, and only rose above 50% after the age of 11-12. Thus the boys were even worse at analogical reasoning than Lunzer had predicted. Even the 16 year olds were only solving about 60% of the harder problems. For the numerical analogies, the performance of the youngest boys was even worse, rising from 12% correct at age 9 to 50% correct by ages 11-12. By 17 years performance levels were at around 90%, however.

Lunzer concluded from these results that analogies required more complex processes of reasoning than were available at the concrete operational level, stating "Even the easiest verbal analogies of this form are beyond children at the concrete level of reasoning." (p. 40). He suggested that the main barrier to analogical reasoning concerned the "apprehension of second-order relations", by which he meant the relations between relations, or between the $a:x$ and $b:y$ terms. These were harder to appreciate than first-order relations, which link the a and x terms and the b and y terms. Thus to solve analogies, children must be able to extract the relation between the a and x terms (first-order), and then construct this relationship in a different realm to match the b term to the correct y term (second-order). It is this second-order relational reasoning which is held to be too difficult for children under 12 years to grasp.

However, there are a number of problems in accepting this conclusion. Firstly, both the verbal and numerical analogies also test the possession of other skills, which are separate from the

ability to reason analogically. These include the possession of quite difficult mathematical skills for the numerical problems, such as cubing numbers and multiplying fractions. A child who does not know about cubing numbers could not even extract the first-order relation from a series of numbers such as 5:125, 4:64 etc., let alone apply this relation to solve the analogy. Younger children may not be very good at these mathematical skills, and this could explain their apparently poor analogical reasoning. Lunzer should have included a control condition checking for the possession of these skills per se.

Secondly, there is no control for vocabulary level in the verbal analogy problems. This could explain the poorer performance of the younger boys, as the vocabulary level could have been too high for them and caused difficulties which were nothing to do with their analogical reasoning skills. A third problem is the exclusive testing of boys. If girls had been tested as well, sex differences may have arisen which may have helped to explain the low patterns of performance. For example, girls may have coped better with the verbal analogy problems, since it is well documented that girls are advanced in verbal skills as compared to boys (e.g. Maccoby and Jacklin, 1975). This would then have led to the possibility that verbal factors rather than analogical ability contributed to the poor performance of the younger subjects. A final problem is that the verbal problems require the ability to solve multiple choice tasks, and Lunzer does not check whether younger children are capable of handling this kind of problem format. If they are unable to deal with multiple choice presentation in the first place, then nothing can be concluded about their analogical skills.

Levinson and Carpenter (1974) also claimed that true analogical

reasoning depended on an understanding of proportionality. They argued that two different types of analogies were given to young children in standardised testing situations: "quasi-analogies", and "true" analogies. In quasi-analogies, the semantic features important for the analogy are specified for the child, (e.g. "A bird uses air, a fish uses ?"), whereas in true analogies the relationship between the $a:x$ term and the $b:y$ term must be worked out by the child (Bird:air::fish: ?). They argued from this that younger children may be able to solve the analogies included on standard intelligence tests only because they are not true tests of analogical reasoning.

For Levinson and Carpenter, the main feature which distinguishes quasi-analogies from true analogies is that, for a true analogy, the relationship between the terms of the analogy "exactly parallels that of a statement of proportionality" (p. 857). For example, 'Bird is to air as fish is to water' can also be expressed as 'Bird is to fish as air is to water', and this parallels mathematical proportions such as $3:4::15:20$ and $3:15::4:20$. Hence for Levinson and Carpenter, an equivalence of proportions is the defining feature of true analogies. The same proportionality is not true of quasi-analogies, as here the relationship is explicit, and so cannot be rearranged: while it is correct to say "A bird uses air, a fish uses water", it is meaningless to say "A bird uses fish, air uses water".

Levinson and Carpenter went on to link their analysis of quasi-versus true analogies to the understanding of proportionality per se. They argued, quoting Lunzer (1965), that an understanding of proportionality was central to the understanding of true analogies. They stated that true analogies will not be solved until 12 years plus, when the understanding of proportionality develops. The same

does not hold for quasi-analogies. So children under 12 should be able to solve quasi-analogies but not true analogies, whereas children over 12 should be able to solve both.

Levinson and Carpenter tested this hypothesis by giving children aged 9, 12 and 15 years verbal analogies to solve, which were either quasi-analogies or true analogies. The same items were used for each type of analogy, and vocabulary level was controlled at three years below the subjects' chronological age. Word association was also controlled, so that the y term used was a very low associate of the b term, association being around 0.08. The order of receiving the quasi-analogies and true analogies was counter-balanced across subjects, administration of the two problem types being separated by one week.

Following the tests, four of the children in each group were asked to explain their choice of answer, to assess the childrens' understanding of proportionality. An understanding of proportionality was inferred if the child gave an explanation which demonstrated an understanding of the relationships both within and between each part of the analogy. Thus for the analogy "Foot is to inches as minute is to seconds", a child who explained that inches are segments of a foot and seconds are segments of a minute was scored as understanding proportionality.

Levinson and Carpenter found that the 9 year olds performed significantly better on the quasi-analogies than on the true analogies ($p < 0.01$), whereas the 12 and 15 year olds were equally good at both. Mean scores out of 16 for each age group for quasi- and true analogies were respectively 10.21 and 8.00, 13.86 and 13.07, and 12.57 and 12.36. The performance of the 9 year olds differed

significantly from that of the 12 and 15 year olds, but the two older groups did not differ significantly from each other. There was also an order effect, with performance on the true analogies being significantly better if the quasi-analogies were presented first than if they were presented second. Finally, the protocol data showed that there was a significant increase with age in the number of explanations which reflected an understanding of proportionality for the true analogies.

Levinson and Carpenter concluded that even 9 year olds could solve true verbal analogies 50% of the time, when word association and vocabulary level were controlled. This performance was much better than was predicted, and it is a pity that a younger age group was not included to see whether younger children would also be capable of solving true analogies, especially as the order effect suggested that analogical performance improved once it was clear what the true analogy task involved. Levinson and Carpenter went on to argue that the predicted link between analogical ability and the understanding of proportionality was supported by the significant increase in proportional explanations found with age.

However, this finding is only based on four children from each group, and is a purely correlational relationship in any case. The fact that the number of proportional explanations and the number of correct solutions both increased developmentally does not necessarily mean that the former caused the latter. It cannot be argued that the increased understanding of proportionality caused the improvement in analogical reasoning, as it could equally be the case that the improvement in analogical reasoning caused the improvement in the understanding of proportionality. Alternatively, the relationship

between the development of proportionality and analogy could have arisen from the development of some third factor, such as verbal skills. Thus from the data presented, little can be concluded about the relationship between proportional reasoning ability and analogical reasoning ability.

2.3.ii. Conclusions concerning the link between proportionality and analogy

It is clear that empirical attempts to show a causal relationship between the development of proportionality and the development of analogical reasoning have been unsuccessful. The reasoning concerning the link between proportionality and analogy has been purely tautological: analogy is assumed to require an understanding of proportions, and so it is assumed that a child who can solve analogies must also understand proportions, and thus that one provides an index for the other. While the authors believe that this position is supported by the work of Piaget and Inhelder (1958), Piaget and Inhelder do not seem to hold such a position, as shown in section 2.1. On the contrary, they seem to be arguing that some analogical ability is already available during the stage of concrete operations.

2.3.iii. Studies of verbal analogies and associative responding

The link between proportional reasoning and analogy was not the only concern of early work on analogy. Another issue concerned the widespread use of a multiple choice format to test analogical reasoning. Some authors argued that multiple choice formats may encourage associative responding, and hence falsely produce apparent analogical reasoning (Willner, 1964). Willner argued that apparent

success on verbal analogies could be achieved on the basis of word association, so that the y term could be found without any understanding of second-order relations. For example, the analogy hat:head::shoe:? could be solved simply by the word 'shoe' evoking the response 'foot', without any construction of the relationship between 'hat' and 'head' and its application to the b term 'shoe'.

Willner tested this hypothesis by giving 130 college students the b term from 46 verbal analogy problems, taken from assessment tests such as the Stanford-Binet (Terman and Merrill, 1960), and the Army Alpha (Wells, 1941). He also presented a further 219 b terms in multiple choice association tests, asking subjects to choose the word most closely related to the b term from 4 alternatives (e.g. shoe: arm, table, foot, lamp). He found that 58% of the former problems and 45% of the latter were correctly 'solved' by this word association format alone. This suggests that verbal analogy problems may not be testing analogical reasoning at all, but may instead test word association skills.

Aachenbach (1970, 1971) examined the extent to which word association affected young children's performance on multiple choice analogy problems. He developed a test of associative responding which consisted of multiple choice analogy problems, half of which had candidate y terms which were high associates of the b terms but incorrect responses to the analogy problem. These items, called 'foils', were meant to assess the degree to which the children were responding on an associative basis. An example of a problem with a 'foil' would be: 'Pig is to boar as dog is to (cat/wolf)'. Here the correct response is 'wolf', and the strong associate 'cat' is the foil.

Aachenbach argued that the number of foils chosen by a child relative to all her other errors would indicate the degree to which a child was relying on word association to solve the verbal analogies. He found that 11 and 12 year old children who made an excess of foil errors tended to have lower IQs and poorer scholastic achievement than children who did not make many foil errors. These trends were maintained at a follow-up two years later.

Aachenbach suggested that associative responding on verbal analogy tests could be used as a way of identifying children who were not using their full reasoning abilities in school. By implication, these children are not using formal operational reasoning strategies. However, as Aachenbach did not give younger children his associative responding test, it cannot be ascertained whether these associative responding strategies are characteristic of children at an earlier stage of development (e.g. concrete operations), or whether they are simply characteristic of children with low IQs. This question could be solved by using Aachenbach's test with younger age groups, to see if the percentage of errors which are 'foils' decreases with age, or only varies with IQ.

It is important to know whether young children rely on word association to solve verbal analogies, as a number of intelligence tests intended for young children include such verbal analogy problems as tests of analogical reasoning (e.g. the Wechsler and the Stanford-Binet). However, one way of avoiding the problems associated with verbal analogies is to test analogical reasoning using a different kind of task. This was the approach taken by Piaget, Montangero and Billeter (1977), who used a picture choice format to examine analogical reasoning skills in children. This work will now

be reviewed.

2.4. Piaget's Stage Model of Analogical Ability

In some relatively recent work, Piaget, Montangero and Billeter (1977) have proposed a stage-model for the development of analogical reasoning which does not depend on proportionality. They state that the development of analogical reasoning is a perfect example of the development of formal operational structures, as analogical development builds on a succession of abstractions made during the pre-operational and concrete operational periods.

2.4.i. The experimental technique

The model is based on experiments which looked at children's ability to form analogies of the traditional form $a:x::b:y$. These experiments used pictures to assess relational understanding, so that vocabulary level was not a problem. Children aged from 5 years upwards were given pictures to sort into "pairs that go together", and were then asked to combine the pairs into "sets of four that go together". The pictures were simple objects and relations, such as dog, hair; bird, feathers; ship, rudder.

If the children did not find pairing of the pairs of pictures easy (the analogy task), hints were provided. For example, the pair 'bird:feathers' ($a:x$) was placed in front of the child, and the experimenter said "What helps the bird to keep warm?"..."The feathers." The picture of the dog (b term) was then placed underneath the bird, and the child was asked "Which picture would go well here (indicating the gap for y)...Try and choose what is to dog as feathers are to bird." If the child still could not choose correctly, 3 possible alternative pictures were offered from which a y term had

to be selected. If the correct relational pairs were formed, the children were given countersuggestions. Thus for the analogy bicycle:handlebars::ship:rudder, the child might be asked "Would a bell also go with the bicycle?...Then what would you have to choose for a ship?" (a siren), and so on.

From the performance of children on this task, Piaget, Montangero and Billeter identified three separate stages of analogical development. These stages will now be discussed.

2.4.ii.Stage I

Stage I is consistent in developmental terms with the pre-operational period, a period in which children's cognitions are dominated by their perceptions. Children in this stage (5-6 years) are unable to identify the first-order relations between pairs of pictures consistently, and are usually unable to construct second-order or analogical relations. For example, Cou (5;3), in stage IA, would sometimes pair objects by the correct relations (bicycle-handlebars), but would often pair objects by quite idiosyncratic relations (e.g. ship-bird: "Because you can sometimes see birds at the lake"; vacuum cleaner-ship: "Because it looks like a ship").

Children in stage IA thus make very subjective pairings of objects, as would be expected from Piaget's notion of egocentricity. As their basis for choosing pairings is essentially arbitrary, the properties on which pairings are based are variable, and so cannot be inserted into a fixed framework of classes and sub-classes. This means that subjects at stage I feel free to bring together any of the pairs, as they can always think of a final relationship to link them

together.

For example, Cou was shown the analogy ship:bicycle::rudder:handlebars, arranged in matrix form so that the a:x term was vertically above the b:y term. She said that they went together because one diagonal (bicycle:rudder) was things that rolled, and the other diagonal (ship:handlebars) was things that didn't roll. When the pictures were separated so that ship:rudder::bicycle:handlebars, Cou put the bicycle back with the ship "because it is next to the water".

Some children in stage I are able to form first-order relations correctly, but cannot extend this to second-order relations. Piaget called this stage IB. Can (5;8) was able to pair bird:feathers ("otherwise it can't fly"), Hoover:plug ("else one can't Hoover"), bicycle:handlebars ("so it can go"), and so on, but could not deal with second-order relations. For example, he chose to pair car:petrol::bicycle:handlebars, because "This is a car, this is a bicycle, both are for travelling on the road". For bird:feather he would only accept dog:hair, but because "the dog eats the bird, those are the feathers"!

Thus it seems to be the lack of stable elementary relations for forming first-order pairs which prevents the formation of second-order relations. Just occasionally a momentary glimmer of analogical reasoning may be seen, usually concerning action, for example, bicycle:handlebars and ship:rudder go together because "that's for steering" (Cou, Stage IA).

2.4.iii. Stage II

The second stage covers the period from 7-8 years to 11-12

years, the period of concrete operations. The behaviour of children in stage II can be divided into two substages, as follows: in stage IIA, children can classify pictures correctly according to relations between relations through trial and error, but are unable to exclude false countersuggestions which destroy the analogy. In stage IIB, children consolidate these skills, and become better at rejecting countersuggestions.

For example, Mag (6;9), a child in stage IIA, was able to pair all the pictures without difficulty. When asked to form an analogy with the pair bird:feathers, he immediately chose the pair dog:hair. His reason for doing so was that they were "two animals". When asked about the relation between feathers and hair, he said "They are both what animals have on them". He also correctly paired boat:rudder with bicycle:handlebars. However, he was quite happy to accept bicycle:pump as a replacement for handlebars "to blow up the tyres", saying both went together with the boat. When asked if pump and rudder went together, he replied "No, the handlebars for both". The pairings of relations is therefore still in an early stage, and susceptible to countersuggestions.

Piaget suggested that the same process controlled both the increasing stability of the pairings of objects made by the children (the first-order relations), and the growing recognition of relations between relations (second-order relations). This was the ability to construct classes. The construction of classes is completely absent from stage I, but in stage II enables the children both to consolidate elementary relations between terms and to consider their extension and their common qualities. This enables the application of class-type relations to pairs of terms (e.g. Mag's class of "animals"

includes the notion of what animals have on them), and the beginning of the formation of analogies.

Even so, children at stage IIA still give way when confronted by counter-suggestions. This becomes less true as they progress to stage IIB. Pat (10;1), in stage IIB, was asked the same question as Can about the pump replacing the rudder in the analogy bicycle:pump::ship:rudder. He replied "No, the handlebars are better, because without handlebars you cannot steer the bike...the pump goes with the bike but not with the ship, and the rudder is almost the same thing, it's for giving direction". However, children in stage IIB can still be misled by counter-suggestions on some occasions. Dav, (8;2), who correctly paired bird:feathers with dog:hair accepted the replacement of feathers by nest, saying "It would still go...but the nest has no hairs, the dog has its hair and one would no longer know what else the bird might have".

This inconsistency when faced with counter-suggestions is what differentiates children at stage IIB from children at stage III. Children at stage IIB begin to recognise that the same relationship is required between AB and XY as well as between AX and BY, but are still prepared to think of feebler relations to allow the inclusion of counter-suggestions, even though they state that these relations are less important or go less well. At stage III, this flexibility disappears, and false counter-suggestions are immediately rejected.

2.4.iv. Stage III

Stage III is the stage of full analogical ability, and usually begins in the period of formal operations, which children reach at around the age of 12-13 years. In stage III, children become able to

group the pairs of pictures by second-order relations quite naturally and without any hesitation. They can also imagine alternative permissible relationships without any difficulty, which is not the case earlier, and understand that analogies can be expressed as proportions, using '=' (e.g. plug/hover = petrol pump/car).

Clearly, it is only in the final stage III that children are able to reason analogically with complete consistency. This means that true analogical ability is not attributed by Piaget to children before stage III, which is reached by most children at around 12 years of age. However, the possibility remains that much younger children may be able to reason analogically in more concrete or practical situations such as those involving schemes of action, and children are clearly capable of forming analogical relations by stage II, which can arise as early as 6;9 years (e.g. Mag.).

2.4.v. Criticisms of Piaget's Model

Piaget's method has been criticised by Gallagher and Wright (1977), who argued that the use of pictures forced the children to attend to observables, which was precisely what had to be overcome in analogical solutions. They therefore gave children written word problems in an attempt to replicate Piaget et al.'s results, and asked children to provide a written explanation for their choice of answer. The problems were of the format 'a:b::c:X1,d,X2,X3', as in 'Automobile is related to gas as sailboat is to (travel/wind/sails/rudder). Following Piaget, a plausible counter-suggestion was included as one of the possible answer options (here = 'sails'). 90 children aged from 10-12 years took part in the study.

Gallagher and Wright found that improvement in analogical solution was strongly related to age, the older children performing better than the younger children. They also analysed the written explanations of the chosen responses, in order to gauge the percentage of 'symmetrical responses'. A symmetrical response was one based on a comparison of both halves of the analogy, rather than one based on only the second (c:d) half. An example would be "An automobile gets its energy from gas and a sailboat from wind. They both need something to make them go." An explanation such as "You need a rudder for the boat" would be scored as asymmetrical. Gallagher and Wright's argument was that true Piagetian analogical ability was based on symmetrical reasoning.

Gallagher and Wright found that the percentage of symmetrical responses given increased with age. They then used multiple regression techniques to show that the percentage of symmetrical responses was a significant predictor of analogical performance even once IQ was partialled out. While this might suggest that analogical ability depends on symmetrical responding (meant to demonstrate proportional understanding), as demonstrated previously there is no a priori reason to assume that an understanding of proportionality precedes an understanding of analogy. Hence there is no particular justification for taking symmetrical responding as the independent variable. Gallagher and Wright do not report whether they performed a multiple regression to examine whether analogical performance was a significant predictor of symmetrical responding, but it seems likely that it would be. Thus there is no reason from this analysis to conclude that symmetrical responding is a precursor of analogy. Gallagher and Wright do not seem to contribute anything further to Piaget's analysis, which is not surprising given the narrow age range

studied.

In a related paper (Gallagher and Wright, 1979), they went on to look at how the content of analogical problems could affect performance. They identified two types of analogies among the problems given in the above study: concrete, where solutions were based on directly observable features; and abstract, where solutions must be based on higher-order rules. A concrete item would be 'Picture is related to frame as yard is to (swings/tree/children/fence)'. An abstract item would be 'Food is related to body as rain is to (water/storm/coat/ground)'. 260 children aged from 9 to 12 years were given ten items of each type, and were asked for written explanations of their answers as before. Gallagher and Wright found that abstract items were significantly more difficult than concrete items, with performance on concrete items being high at all ages, but performance on abstract items improving with age. Again, the percentage of symmetrical explanations provided for the answers chosen improved with age. They concluded that a shift in performance on abstract items occurs at around 12 years of age, supporting Piaget's model, but that this is not true of concrete items. They argued that concrete items could be solved by association, and that an understanding of proportionality was therefore not required.

Again, this conclusion can be criticised. Gallagher and Wright should have included younger children in their study, in order to determine whether younger children could also solve concrete analogies, as would be required if such analogies are only based on associative reasoning. No independent evidence of this is offered, and for the concrete example given the response 'tree' seems just as

plausible an association as 'fence'. Furthermore, the conclusion that successful analogical performance depends on proportional understanding is only based on the finding that the older children gave more symmetrical responses than the younger children. As shown before, such evidence is entirely tautological, and no conclusions about cause and effect can be made from such data. Hence Gallagher and Wright do not make a convincing case for the link between proportional understanding and analogy. It is surprising that the same concerns which dominated the early work on analogical reasoning should recur, and further that they should be studied in exactly the same way.

Let us turn now to a consideration of some very different work based on Piaget et al.'s developmental model. This is the work which attempts to use the experimental methods of information-processing research to examine analogical development.

2.5. Information Processing Analyses of Analogical Reasoning

Piaget's stage model of analogical development has been widely adopted by information-processing theorists of analogical reasoning. They have taken the three stages identified by Piaget et al. as a starting point for their attempts to quantify the mental components involved in reasoning by analogy. However, these theorists tend to assume that Piaget believes that analogical reasoning is completely absent at stage II. As these theorists have equated stage II with concrete operations and stage III with formal operations, this has unfortunately caused them to make some misleading predictions.

2.5.i. Sternberg's Model: Theory

By combining the work of Piaget with that of Lunzer, Aachenbach,

and Levinson and Carpenter, information-processing theorists such as Sternberg and Downing (1982) have argued that analogy is a useful task for differentiating between children at the stage of concrete operations and children at the stage of formal operations. They make this differentiation by introducing three stages of their own in the development of reasoning by analogy. The first stage is marked by associative responding, as children at this stage cannot discern second-order relations in analogies. The second stage marks the transition between concrete and formal operations, children at this stage showing a preliminary ability to deal with second-order relations. The third stage is characteristic of children in the formal operational stage, as children now display full understanding of second-order relations. From this model, Sternberg and Downing argued that the strategy which children adopt to solve analogical problems can be used to distinguish between concrete and formal operational children.

Sternberg and Downing went on to present a theory of analogical reasoning stated in geometric terms, which was based on strong assumptions about the link between proportional understanding and analogical reasoning. They suggested that words can be viewed as occupying locations in an n -dimensional semantic space of unknown full dimensionality. The terms of an analogy 'a is to x as b is to y' can be represented as vectors in this semantic space. A perfect analogy is then represented as a parallelogram, where the vector 'a is to x' (AX) is equivalent to the vector 'b is to y' (BY), and the vector 'a is to b' (AB) is equivalent to the vector 'x is to y' (XY). The goal of a subject trying to solve an analogy is to match the magnitude and direction of AX and BY as closely as possible in semantic space.

Sternberg and Downing specified six information processing components required to solve a given analogical problem. A subject must first encode the terms of the analogy, so that the locations of the terms in semantic space can be established. Next, the subject must infer the relation between the a and x terms, which Sternberg and Downing conceptualise as establishing the vector connecting a and x. The subject must then map the relation between the two halves of the analogy a and b, and apply a relation analogous to the inferred one to the b term. This application will identify a possible y term, so the subject must then justify this choice as being the most appropriate. Finally, the subject must respond with the chosen y term.

The assumptions underlying this argument can be made clearer through an example, taken from Sternberg and Nigro (1980). In solving the analogy 'apple is to eat as milk is to (white/drink/cow/sweet)', the child has to:

1. encode the terms apple, eat, milk, white, drink, cow and sweet as needed, retrieving from semantic memory a list of attributes for each term that might be relevant for analogy solution
2. infer the relation between apple and eat: one eats an apple
3. map the second-order relation between the first half of the analogy and the second: both concern operations performed on foods
4. apply an analogous relationship to that of apple:eat from milk to at least some of the answer options (e.g. white, drink), seeking an option that bears the same relation to milk that eat does to apple
5. justify one response as preferred to the others if none seems ideal (not necessary in this example)
6. respond with the chosen option ("drink")

2.5.ii. Sternberg's Model: Data

The role of these assumed different component processes in children's analogical reasoning strategies was examined by Sternberg and Nigro (1980). They argued that these component processes could be combined in several different ways to solve analogical problems, and that by giving children different types of analogical problems to solve, different models of combination could be tested against each other. The contribution of each component to solving the analogy using a given model of combination was deduced by varying the form of the analogies given. For example, if the number of operations required for solution was varied, response time and error data could be used to distinguish between solution strategies. In this way, different models of combination of the components could be compared, for example, exhaustive search models versus self-termination models. The assumption underlying this rationale was that the amount of time taken on each component will sum linearly.

Sternberg and Nigro tested this hypothesis by giving children aged 9, 12 and 15 years and college students three types of analogies to solve. These types were held to differ in the number of operations required to reach a solution, as the number of terms in the analogy stem varied from one to three. The types were:

I. Three-term stem: narrow:wide::question: (trial/statement/
answer/ask)

II. Two-term stem: win:lose::(dislike:hate)(ear:hear)
(enjoy:like)(above:below)

III. One-term stem: weak:(sick::circle:shape)
(strong::poor:rich)(small::garden:grow)(health::solid:firm)

For these three types of analogies, it was assumed that each analogy required use of the components identified above (encoding, inferring, mapping, applying, justifying, and responding), but that the number of executions of each component differed depending on the format of the analogy, the number of answer options, and the assumed model of combination. For example, more encoding was needed for the type III analogies than for the type I analogies in all models, but a self-terminating model would not encode all the terms in each case, whereas an exhaustive search model would. Contrasting these models, Sternberg and Nigro stated that, in the case of the three-term stem example given above and a self-termination model of combination, "Only six terms need to be encoded, and only three relations need to be applied. Because the correct option is the third one, the fourth option need not be encoded, nor need any relation be applied to it." (p. 31). Similarly, the number of inferring, mapping and applying operations would increase with the number of x, b and y terms respectively, whereas the amount of time spent on justification would depend on the degree of association between the candidate y terms and the b term. For example, if one candidate y answer was perfect, this high association would have a facilitative effect.

Multiple regression techniques were then used to indicate the contribution of each component to the prediction of response time or error data. Response time was hypothesised to equal the sum of the amounts of time spent on each of the components. This will vary with the number of times each component is executed (an independent variable), and the amount of time which each component requires (an estimated parameter). Proportions of errors depend on the difficulties of the component processes (an estimated parameter), and the numbers of executions of processes (an independent variable).

Standardised regression coefficients (Beta weights) can then be used to indicate the contribution of each variable to the prediction of response time or error rate (both dependent variables).

From such quantitative analysis of the data, Sternberg and Nigro found developmental differences between the 8 and 11 year old children and the older subjects. The results suggested that the 8 and 11 year old childrens' response patterns depended on the degree of word association between the b and y terms of the analogy, as no increase in response time occurred when the number of inferences required by the analogy form increased. Similarly, the number of errors depended on the degree of association between the b term and candidate y terms. For older children and college students, the degree of association between the b and the y term did not affect error rates, and response time did vary with the number of inferences which had to be made. Sternberg and Nigro concluded that 8 and 11 year old children solved verbal analogies primarily on the basis of word association, whereas older subjects relied almost exclusively on analogical processes in arriving at solutions. The authors suggested that this conclusion supported Piaget's hypothesis that true analogical reasoning was characteristic of the stage of formal rather than concrete operations.

However, the conclusions which Sternberg and Nigro reach cannot tell us how young children perform on verbal analogies when word association is controlled for. The 8 and 11 year olds may have relied more on associative strategies because they were not given problems to solve in which strong associations were not present. It is not clear how Sternberg and Nigro would explain Levinson and Carpenter's (1974) finding that 9 year old children can solve 50% of true

analogies in circumstances where word association cannot be used.

2.5.iii. Componential models based on Sternberg's approach

A componential approach to children's performance on verbal analogy problems was also adopted by Goldman, Pellegrino, Parseghian and Sallis (1982). They gave 8 and 10 year old children verbal analogies to solve in both a free generation and multiple choice format, the same analogies being given on each task. The generation task was given first to all subjects and the multiple choice task followed two weeks later. After being given the multiple choice task, the children were asked to justify their responses. Performance was then analysed in terms of the following components: inferring the relationship between a and x, applying the inferred relationship to b, recognising the correct y term, and the amount of distraction which occurred from alternative y responses. The latter two components could only be measured on the multiple choice tasks.

A probability model of how these components should interact during performance was then derived by using similar assumptions to Sternberg and Nigro, and was used to test the contribution of each component to analogy solution for the different age groups. The results showed that relational application, response recognition and distractor interference were equally important in predicting performance in the multiple choice task. Relational inference was also important, but less so. The main developmental differences were that older children were better at recognising the correct response even if they had generated an incorrect inference, and were also less susceptible to distractor items among the candidate y terms. Large individual differences meant that these factors also differentiated the skilled 8 year olds from the less skilled 10 year olds. A second

study confirmed this componential analysis with new subjects. Thus it seems that poor performance on verbal analogy tasks is characterised by greater distractibility by false associates, and by less powerful process execution.

Goldman et al. argued that their results supported those of Sternberg and Nigro, who also found a reliance by younger and less skilled responders on associative strategies. Goldman et al. used the justification data which they obtained to support this claim. This showed that the older children were more likely to give explanations demonstrating an understanding of parallel or second-order relations than the younger children. The probability of justifying correct responses in terms of parallel relations was also shown to be significantly correlated with overall performance on the multiple choice problems at both ages. Goldman et al. interpreted this result as showing that less skilled subjects have a weaker understanding of why a correct response is analogically correct.

Goldman et al. suggested that this weaker understanding of reasoning by analogy led to greater susceptibility to an associative processing strategy of the type found by Sternberg and Nigro. They argued that apparent evidence for analogical reasoning in younger children "strongly indicate(s) some type of simpler associative understanding of analogy" (p. 558).

There are two points to be made here. Firstly, Goldman et al.'s finding that skilled 8 year olds solved analogies in the same way as skilled 10 year olds does not seem to support the position of Sternberg and Nigro, who are claiming that analogical performance can be used to distinguish between concrete and formal operational children.

Secondly, their use of justification data to support this claim can be criticised. The justification data only shows a significant correlation between the use of second-order relations to justify solutions and correct responding. Such a correlation need not imply that the increased use of justifications based on second-order relations reflects an increased understanding of these relations, which then causes an improvement in analogical performance. It could equally be the case that the improvement in analogical performance causes the increased use of justifications based on second-order relations, or that a third factor such as IQ is causing both these improvements.

Thus it cannot be concluded that the weaker understanding of what is involved in analogy, indexed by poorer verbalisation skills in the low scorers, led them to be more susceptible to using associative processing. It would have been better to test this hypothesis by training the low scorers on verbalisation skills, and seeing if this led to a corresponding decrease in their use of associative processing.

As has been shown, all the claims regarding the development of analogical reasoning in the information-processing literature depend on experiments which use multiple-choice verbal analogies. We turn now to a consideration of whether children can make analogies in more concrete settings.

2.6. Studies of analogical reasoning in solving concrete problems

Recently, two studies have appeared which examined the use of analogical reasoning in solving concrete problems. These studies suggest that young children's analogical skills may not be as weak as

so much of the literature implies. The approach taken is markedly at variance with the deficit approach taken by all the other workers in this area.

For example, Gentner, (1977), examined what she calls 'spatial analogies'. Gentner argued that the fundamental requirement of analogical reasoning is the ability to preserve semantic relationships while mapping from one domain to another, by which she meant preserving the $a:x$ relationship in constructing the $b:y$ relationship, or more generally the ability to form second-order relations.

Gentner suggested that by posing analogical problems in a spatial context, children's ability to preserve semantic relationships across domains could be measured without encountering any of the problems associated with vocabulary constraints and knowledge of semantic features, problems endemic to using verbal analogies. She argued that, as young children have a well-developed understanding of their own bodies, they should have no difficulty in understanding the domain of the analogy if asked to map their own body parts onto other environmental entities, such as trees and mountains.

Gentner asked 4 and 6 year olds and college students questions like "If a tree had a knee, where would it be?", and "If a mountain had eyes, where would they be?". Subjects had to respond by marking the relevant location on pictures of trees and mountains, which could be presented in four different positions: upright, upside-down, or sideways to the right or left. Gentner found that children were as good as adults at predicting where the features would be, and in some cases were actually better. From this she concluded that even

pre-schoolers have well-developed analogical abilities.

It could be argued, however, that these skills are unique to the spatial field. Such a criticism would be weakened by evidence from a very different study, that of Holyoak, Junn, and Billman (1984), which also showed good analogical reasoning by pre-schoolers. They asked children to solve a problem that allowed multiple solutions, and compared performance on the problem presented alone with performance after hearing a story which contained an analogous problem and its solution. 30 children aged 4-6 years and 18 children aged 11-12 years were given the problem of transferring some small rubber balls from one bowl on a table to another bowl further away, which was out of the children's reach. On the table were a selection of materials which could be used to help solve the problem, such as a large sheet of heavy paper, an aluminium cane, a long hollow tube, scissors, string, and so on. The children had to devise as many ways as possible of transferring the balls from the filled to the empty bowl without leaving their seat.

Two story analogues were used. In both stories, a genie wanted to transfer some precious jewels from one bottle to another. In one story, he solved the problem by using his 'magic staff' to pull the new bottle over to the side of the old bottle. In the other story, the genie commanded his magic carpet to roll itself into a tube, and used it to roll his jewels from one bottle to the other. Analogous solutions in the rubber balls problem would thus be using the aluminium cane to pull the far bowl nearer (the cane solution), and rolling up the paper into a tube so that the balls could be rolled through it (the paper solution).

Children were tested individually in three conditions; magic

staff story, magic carpet story, and control. In the first two conditions, the children were given the rubber balls problem to solve after listening to one of the stories, in the control condition they received the problem alone. Children in the two experimental conditions were not told that the story could help them until they became stuck on the rubber balls problem. At this point a hint to use the story was given, the experimenter asking what the genie did, and asking if the children could do something similar.

Holyoak et al. found that all the preschoolers were able to devise the cane solution to the rubber balls problem by applying the magic staff analogy. Half of the children did so without needing a hint, whereas in the control condition only one child thought of this solution. In the magic carpet condition, only 3/10 children rolled up the sheet of paper into a tube to produce a fully analogous solution, all without receiving a hint, while none of the children in the control condition did so. In contrast, 9/10 children came up with the partially analogous solution of using the cardboard tube. However, as 8/10 children in the control condition also used the cardboard tube solution, tube use was probably not dependent on analogy. For the older children, everyone given the magic carpet story produced an analogous solution for the rubber balls problem by rolling up the sheet of paper. Thus significantly more analogies were made by the older subjects in this condition.

Pre-school children can obviously use analogy to solve problems in some situations (the magic staff condition). However, it could be argued that they were succeeding because the magic staff and the cane were perceptually and functionally more similar than the magic carpet and the piece of paper. To check that it was not perceptual and

functional similarity which enabled the younger children to succeed on the rubber balls problem, Holyoak et al. went on to give other children (4-7 year olds) three different stories before giving them this same problem. All three stories involved the magic staff solution, but in two of the stories this solution was incidental to the main story line.

Holyoak et al. found that use of the cane solution in the rubber balls problem fell significantly for the less directly-analogous stories, with only one child out of 5 in each of these conditions devising the cane solution in spite of extensive hints. From this, Holyoak et al. argued that the perceptual and functional similarity of the cane and the staff did not explain the analogical responses of the children in Experiment 1. However, this conclusion relies on a negative result (i.e. that the children did not come up with the cane solution). Better evidence for analogy in the magic staff story would be provided if essentially the same story was given, but with the magic staff being replaced by something less perceptually and functionally similar to a cane, such as a magic rope. If the children still made an analogy to the cane, this would be an analogy based on the principle of the story rather than one based on perceptual or functional similarity, and so would provide positive evidence for the use of analogy in the magic staff story.

Holyoak et al. went on to show that 4-6 year olds could also use the magic carpet analogy successfully if the subject of the story was made more familiar (Snoopy rolling up a blanket to transfer eggs, Miss Piggy rolling up a carpet to transfer jewels). This showed that perceptual and functional similarity were not necessary conditions for analogy to be used in problem solving by pre-schoolers. These

story formats provide a better test of analogical reasoning anyway, as they do not rely on magic. The use of a genie may have caused some children to suspend logic when listening to the stories, and thus may have prevented them from considering any logical relationship between the stories which they were told and the rubber balls problem. It can be concluded that children as young as 4 years can use analogy to solve problems, as long as the analogy is a simple and direct one.

2.7. Conclusions

It is clear that the majority of psychologists whose work is reviewed above see analogical reasoning as a relatively sophisticated ability, characteristic of children aged 10-12 and above. Successful performance on analogical problems by younger children is generally assumed to reflect the use of associative reasoning. However, some recent work challenges this view (see section 2.6.), and shows that even pre-schoolers can reason analogically. If this is so, then children should be able to use analogies to help them to learn to read and spell as soon as they are introduced to written language. This possibility is considered in Chapter 3, which looks at the work that has been done on the use of analogies in learning to read and spell.

CHAPTER THREE

STUDIES OF CHILDREN'S USE OF ANALOGY IN READING AND SPELLING

3.1. Introduction

There are very few studies on children's use of analogy in reading and spelling, and the work that has been done is inconclusive in terms of specifying what, if any, developmental changes occur. Again, a generally pessimistic view of young children's analogical abilities characterises the main work in the field.

Analogy in both reading and spelling has largely been examined through the use of nonsense words. Children are given nonsense words either to read or to spell by analogy to real words. An example would be 'yave', which can be read by analogy to 'gave'. Studies which use nonsense words will be considered first. The few studies which look at reading real words by analogy to other real words will then be reviewed.

3.2. Studies with nonsense words

3.2.i. Analogies in reading

Marsh, Desberg and Cooper (1977) asked children aged 10 and 16 (fifth and eleventh grade) and college students either to read a list of ten nonsense words aloud, or to choose a pronunciation for the same nonsense words from two possible pronunciations provided by the experimenter. The ten nonsense words were selected so that a pronunciation based on analogy (e.g. 'puscle' read like 'muscle') would differ from one based on phonics. By phonics Marsh et al. meant individual letter-sound correspondences, such as 'c' -> /k/, which

would give the pronunciation 'puskle'.

Marsh et al. found a developmental increase in the number of responses which were analogous for both tasks. Younger readers tended to prefer grapheme-phoneme pronunciations to analogous pronunciations, significantly more responses in the free response condition being grapheme-phoneme responses than analogy responses (49.5% and 39.1% respectively). This trend was reversed in the two older groups, where analogy responses were significantly more frequent than grapheme-phoneme responses. Analogies were made on 45.5% and 59% of responses by the 16 year olds and college students, respectively, while grapheme-phoneme responses were made on 44% and 30% of occasions by these age groups.

To avoid the possibility that analogical performance might depend on reading vocabulary rather than on the use of analogy per se, the contingent probability between knowing the analogue and using an analogous pronunciation for the corresponding nonsense word was calculated. This contingent probability was significant at all ages, indicating that if a child had the basis for making an analogy, she would usually do so.

The authors took the change in preference for using an analogy strategy with age as evidence for a stage model of reading. The stages which they proposed were, respectively, 1. linguistic guessing, where the child simply makes a plausible guess based on linguistic context; 2. discrimination net guessing, where the child guesses on the basis of both visual similarity and linguistic context; 3. sequential decoding, where the child decodes unknown words letter-by-letter using grapheme-phoneme rules; and 4. hierarchical decoding, where the child uses 'higher-order' rules

(such as the rule that a terminal 'e' lengthens the vowel) and analogy. Analogical strategies are thus meant to be characteristic of the final stage of reading development, while grapheme-phoneme conversion strategies are characteristic of an earlier stage.

There are problems with accepting this interpretation. Firstly, it is dangerous to base claims about a stage model of normal reading development on a study using nonsense words. Children could use unusual strategies to read nonsense words, strategies which are not typical of their normal reading behaviour. Secondly, the stages found by Marsh et al. may be artifactual. This is because they did not check whether the 10 year old children had the words from which analogies were meant to be made in their reading vocabularies. Nonsense words like 'cetto' and 'biety' were used, which were meant to be read by analogy to 'cello' and 'piety'. These real words seem quite hard for the younger children, which could explain the low levels of performance found in the experiment. It is quite possible that the younger children were poor at the task because they did not have the real words from which to make analogies available in memory, rather than because they could not make analogies in reading until later in development.

This interpretation is supported by the finding that the younger children, when probed after the task, were less likely to produce the analogous real words than the older children. Even though Marsh et al. presented information about the contingent probabilities between knowing an analogue and making an analogy, this is not convincing evidence for a developmental model since knowledge of the analogue was only probed after the nonsense word task. The children may not have responded on the basis of the analogue in the test phase, and

may only have thought of possible analogies after being asked about them. The significant contingent probabilities may simply indicate that if a child read a nonsense word correctly, she was later more likely to think of a real word analogue than if she could not read the nonsense word in the first place. Thus this study tells us very little about whether children can use analogies in reading, and its conclusions are open to alternative interpretations.

The same is true of a study reported by Marsh, Friedman, Welch and Desberg (1980a). This time children aged 7 and 10 years and college students were given two passages of prose to read, which had nonsense words in some of the noun positions in the story sentences. Four of these words assessed the subjects' use of analogy, as pronouncing the words by analogy to a real word led to a different pronunciation from that produced by the application of spelling-sound rules (e.g. 'faugh' would be pronounced "faff" by analogy to 'laugh' (Californian English), but 'faw' via spelling-sound rules).

Marsh et al. found that analogical responses were given on 14% of occasions at age 7, 34% of occasions at age 10, and 38% of occasions at college level. The difference in analogy use between age 7 and age 10 was significant; however, the increase in the use of analogy from age 10 to adult was not significant, a result which differed from the 1977 study. Marsh et al. concluded that the analogy strategy was available by the final stage of reading development, but that its use was strongly determined by task factors.

Again, however, Marsh et al. did not check that the younger subjects knew the real words from which they were meant to make analogies. Thus the 7 year olds could have made fewer analogies

because they did not know all the analogical real words, rather than because they were less capable of using analogy than older readers. So this study also does not establish whether children can use analogies in reading.

3.2.ii. Analogies in spelling

Marsh, Friedman, Welch and Desberg (1980b) then carried out a study of the use of analogy in spelling, based on a similar rationale. Children aged 7 and 10 years and college students were given nonsense words such as 'jation' (nation) and 'zoldier' (soldier) to spell to dictation. They were also asked to spell analogous pairs of nonsense words, such as 'cazical-cazicise' (critical-criticise), and 'cuscle-cuscular' (muscle-muscular). Marsh et al. found that the percentage of analogies made on the single nonsense words was 0% at age 7, 33% at age 10, and 50% at college student level. Similarly, the percentage of analogies made in spelling the pairs of nonsense words was 3%, 10% and 24%, respectively.

Marsh et al. argued that these figures showed "a marked developmental increase" (p. 351) in the use of analogy, similar to that found in reading in the 1977 study. They concluded "There appears to be a marked developmental shift in the use of analogy strategies in both reading (Marsh et al., 1977) and spelling between the second and fifth grade...We must conclude therefore that there are qualitative differences between the strategies used by beginners and skilled readers and spellers" (p. 351).

Again, however, the study is open to the criticism that the younger children may not have known the real words to which analogies

were meant to be made, and that this explains their poor use of analogy. Words like 'soldier' and 'nation' would be quite hard for 7 year olds to spell, and word pairs like 'critical-criticise' would probably even cause difficulties for 10 year olds. Marsh et al. should have checked that these words were in the spelling vocabularies of their subjects before drawing conclusions about the ability of these children to use analogies in spelling. Again, we are left with the possibility that young children may be perfectly capable of using analogies in spelling. The claim about qualitative developmental differences in strategy use is not substantiated by this work.

3.2.iii. Analogies in reading and spelling

Some of the problems outlined above are overcome in a later study by Marsh, Friedman, Desberg and Saterdahl (1981). They compared the performance of 7 and 9 year old children and 9 year old backward readers (reading at the 7 year level) on reading and spelling a list of 20 nonsense words. The children were also given a list of the real word analogues, and were told that the nonsense words had been made by changing one letter of the real words. The children were given the word lists to read and to spell, and either received the real words first or the nonsense words. When the percentage of analogical responses was calculated, a developmental increase was again found in the use of analogy. At age 7 the children made 78% analogical responses in reading and 26% in spelling, while at age 9 the levels were 92% and 49% respectively. The backward readers performed at the 7 year level, which Marsh et al. interpreted as evidence for a developmental lag explanation of reading backwardness.

Marsh et al. argued that these results supported the stage model

of reading put forward in their 1977 paper, with analogy only appearing in the final stage of reading development. However, again this conclusion can be criticised. Marsh et al. themselves report that the difference between the percentage of analogies made in reading was not significant (78% vs. 92%). This is clearly not good evidence for a developmental hypothesis.

Furthermore, these figures seem very high in absolute terms, and yet the method of calculating analogical responding is not explained. Presumably it was based on comparisons with the real words given (e.g. 'finger-tinger', 'shepherd-tepherd'). Since the children were explicitly told that the nonsense words were analogues of the real words, this could easily have encouraged them to use analogies more than they might otherwise have done. This could explain the high percentage of analogies made at all ages. Rather than implying that analogical use increases with reading development, this result seems to suggest that children at both ages studied were capable of using analogies to read new words, and did so when effectively told that analogy would be a useful strategy by the experimenter.

Such an interpretation of the results goes against the developmental hypothesis favoured by Marsh et al., which was only supported by their results for spelling. Instead, this interpretation suggests that the ability to make analogies in reading and spelling does not develop at all, but is already present at age 7. The significant differences in analogy use with age found in the 1977 and 1980(a) studies have already been shown to be difficult to interpret, and may also have arisen partly because the usefulness of analogy for reading the nonsense words was not made explicit. When the need for analogy was made explicit and the analogical real words were

presented (i.e. the 1981 study), the use of analogy in reading by children of different ages did not differ significantly.

Furthermore, the method of the 1981 study is also open to the previous criticism that the younger children may have made fewer analogies because they remembered fewer of the real word analogues, even though this time the analogous words were provided in a separate list. This criticism could explain why an apparent developmental increase was still found for spelling.

Finally, as mentioned previously, it is dangerous to make strong claims about stages in normal reading and spelling development from studies using nonsense words, as unusual strategies may be used to read and spell the nonsense words. Thus it is difficult to draw any firm conclusions about the role of analogy in reading and spelling development from this study. Clearly, the argument for qualitative shifts in strategy use with age (1980b) is also not supported.

3.2.iv. Training analogies in reading

In a recent study, Wolff, Desberg and Marsh (1985) again assert (quoting their 1977 and 1981 studies) that analogy is a strategy typical of older, advanced readers rather than younger readers. They then examine whether reading development can be facilitated by teaching younger children to use analogies to read new words. Wolff et al. trained 7 and 10 year old children to use analogy in a nonsense word reading task. A group of 10 year old backward readers reading at the 7 year level were also trained in the same way.

Three training techniques were used. The first involved giving children a real word printed in red on a card, and then asking them to read an analogous nonsense word printed on a separate card. The

second training technique involved the experimenter simply asking the children to 'think of a real word which would be like the nonsense word if the first letter was changed' before reading the nonsense word. The third was a combination of both these procedures. Twenty children in each age group were trained with each method, and their performance on reading the nonsense words was compared to that of a control group given the nonsense words to read in isolation.

Wolff et al. found that all the experimental groups performed significantly better on the nonsense words compared to the control group at all ages, although more nonsense words were read correctly by the older children. There were no differences between the different conditions. Transfer to reading five new nonsense words was then tested, and it was found that most transfer occurred for the children asked to think of their own real word analogues. Wolff et al. suggested that this was because children in the latter condition were required to do the work of finding analogues for themselves. This made them more likely to do this later without instruction. The authors went on to argue that the use of such teaching methods could speed up reading development.

Two main criticisms can be made of this study. Firstly, as shown previously, it remains to be established that younger children are unable to use analogies in reading anyway. As the 1977, 1980 and 1981 studies did not show that younger children were necessarily any worse at making analogies than older children, it is wrong to talk about facilitating development, even if training can be shown to work. Secondly, the claim about speeding up reading development is a big one to make from a comparison of performance on reading five nonsense words. Five words are far too few words to use in testing transfer.

All that Wolff et al. have actually shown is that analogy is a useful way of deriving pronunciations for nonsense words. Again, the danger of making assumptions about real word reading from performance with nonsense words should be mentioned.

In a similar study designed to look at analogy in combination with other reading skills, Baron (1979) gave 9 year old poor readers three lists of words to read, regular ('cut'), exception ('put'), and nonsense ('lut'). Baron found that the nonsense words were pronounced by the children to rhyme with the words they knew, whether these were exception words or regular words. If the children could read the exception word but not the regular word which was analogous to a nonsense word, then the nonsense word was significantly more likely to be pronounced to rhyme with the exception word than with the regular word, whereas if the children knew the regular word but not the exception word, then the reverse was true. These results would be expected if the children were using analogies to read the nonsense words, and Baron suggests that "the use of analogies is a natural mechanism for decoding nonsense words" (p. 67). Baron then went on to train children to use analogies (experiment 3).

Baron trained three groups of children to use analogy to read nonsense words: 6 year olds, 7 year olds, and 9 year old backward readers. Training simply consisted of asking the children to think of other words that they knew which looked like the nonsense words with which they were having trouble. If necessary, prompting was provided. For example, if the nonsense word was 'bew', Baron might say "I don't have enough, I have too ---?", or even show the child the word 'few' and say "If this word is 'few', then what is this one?" (indicating 'bew'). The children were trained in this way on half of the nonsense

words which they were unable to read at pretest. Baron found that after training, all the children made significantly fewer errors on the untrained nonsense words than before training, although the 6 year olds required a lot of encouragement to use analogies. Some subjects spontaneously reported using analogy, however.

From these experiments, Baron suggested that a true analogy mechanism was available to young children. While his results are certainly compatible with such an interpretation, it must be remembered that analogy use was being measured solely by performance with nonsense words. Therefore it is possible that the 'analogy mechanism' is specific to decoding nonsense words, and plays no role in reading development. Furthermore, it is not clear why Baron used backward readers in his first experiment, as no rationale is offered for this. It is not clear whether Baron believes that analogies are characteristic of younger rather than of older readers, and so sees these backward readers as using analogies because they are stuck at an earlier developmental stage, or whether he thinks of analogy as a strategy used equally frequently at all ages. Since Baron does not make systematic age comparisons anyway, the answer to this question cannot be found by looking at his data.

3.3. Studies with real words

3.3.i. Analogies in reading

One study that has looked at the use of analogies in reading real words rather than nonsense words is that of Baron (1977). Baron trained kindergarteners to read sets of simple words and sounds by rote, and then tested transfer to new words. Training sets were words and sounds like 'b', 'at', 'bat', 'ed', 'red', and transfer words

were of two types, those that could be decoded by analogy (e.g. 'bed' and 'rat'), and those which required what Baron called a 'correspondence' method (e.g. 'bad' and 'bet'). By this Baron meant knowledge of the correspondences between single letters and sounds, as he argued that the correspondence words could not be decoded by the use of larger units extracted from the training sets.

Baron found that the children were performing at around 90% correct on the analogous test words, compared to around 15% correct on the 'correspondence' test words. He argued from this that analogy strategies were more natural in the beginning stages of reading than correspondence strategies.

While this is one interpretation of the results, it is not the only conclusion that can be drawn from the data. First of all, half of the 'correspondence' test words could be read by analogy as well, as they contained consonant-vowel units which could be extracted from the beginnings of the training words (e.g. 'bat' -> 'bad'). Thus in principle an analogy could be made between the segment 'ba-' in 'bat' and 'bad'. If analogy strategies are more natural in the beginning stages of reading, children should also use analogy to help them here.

Furthermore, the analogy words differ from the correspondence words in that training on the analogous unit is given for the analogous test words. The transfer information required to read 'bed' by analogy to 'red' and 'rat' by analogy to 'bat' (extraction of the '-ed' and '-at' segments) has been taught to the children already as part of the training set. This means that the 'correspondence' words make more complex demands on the children than the analogous words, as no training has been given on the end segments of the

correspondence words (e.g. '-ad' and '-et'). These words require more difficult segmentation and blending skills than the analogous words. The differences which Baron finds between his transfer words could thus arise for reasons other than the use of analogy. It cannot be concluded from this experiment that kindergarteners are capable of using analogy to read new words.

3.3.ii. Training analogies in reading

Baron (1977) also looked at the effectiveness of teaching analogical skills. He taught eight 5 year old children pairs of words like 'mat' and 'mug' by rote, and recorded the number of errors they made in reaching a criterion of correct reading on two successive trials. He then gave the children new words like 'at' and 'ug' to read, and measured analogical transfer by subtracting the number of errors made in reaching criterion on these new words from the previous error scores. The children were asked to do this for six sets of training and transfer word pairs. Baron predicted that the transfer scores should increase across the six sets as children learned the analogy strategy. Hints to use analogy were also given, children who did not know the new words being encouraged to think of similar words which they had just learned.

Contrary to his hypothesis, Baron found that the children made more errors on the second pair of words before reaching criterion than on the first pair of words, although this tendency declined across the six word sets. Only on the sixth set did the children make fewer errors on the new words, which suggests that they were not learning to use analogy as easily as had been predicted. Although Baron improved his position by re-analysing the transfer data, this time discounting repetitions of the first pair of each set, this

still resulted in negligible transfer of learning to the second pair. Analogy does not seem to help the children as much as might be expected.

An explanation for these poor results may lie in the nature of the transfer pairs. These included 'words' like 'ug', 'um', 'eg', 'al', and 'aw', which are essentially meaningless, although Baron calls them 'exclamations'. These are very peculiar words to expect 5 year olds to produce, and may account for the children's tendency to repeat the first word pair. Production of 'words' like 'ug' could well rely more on phonemic segmentation skills than on analogical skills, and as Baron found during pretesting that all the children failed a test of phonemic segmentation, this could explain their apparent failure to use analogy. Thus the transfer part of Baron's study may not be testing for analogy at all, but rather testing segmentation skills. Again, this experiment tells us very little about kindergarteners' ability to use analogies to read new words.

3.4. Analogies in reading and spelling: conclusion

There is a clear conflict between the position of Baron, who sees analogy as a strategy which can easily be used by kindergarteners, and the position of Marsh et al, who see analogy as a sophisticated strategy which only emerges in the final stage of reading development. However, it is too early to say from the experiments reviewed above whether kindergarteners are able to use analogies to read new words. It is also too early to conclude, as does Marsh, that analogy is a sophisticated strategy characteristic of children in the final stages of reading and spelling development. We will now consider how the cognitive-developmental literature on analogical reasoning reviewed in Chapter 2 relates to the use of

analogies in reading and spelling.

3.5. The link between analogical reasoning and orthographic analogies

In order to relate the work on analogical reasoning in general to the work on analogies in reading and spelling, we will begin by looking at the characterisation of analogical reasoning offered by the studies reviewed in Chapter 2.

3.5.i. The cognitive-developmental view of analogy

A recurring theme in the work reviewed in sections 2.1. - 2.5. was that the solution of an analogy of the form $a:x::b:y$ involved the formation of two sets of relationships. These were termed 'first-order relations', the relations between two entities such as a and x , and 'second-order relations', the relation between relations, or between the a and x and the b and y parts of the analogy. Spearman (1923) called the two types of reasoning involved 'the eduction of relations' and 'the eduction of correlates' respectively. The way in which these two types of relation combine in solving analogies has been most clearly formulated by Sternberg (1977).

Another common assumption in the literature reviewed in Chapter 2 was that the 'eduction of relations' was easier than the 'eduction of correlates', and that the eduction of relations occurred earlier developmentally. First-order relations were held to require only associative responding, whereas second-order relations require a comparison to be made between different relations. The latter was frequently assumed to require an understanding of proportionality, although as demonstrated in section 2.3., the reasoning behind this was largely tautological. Second-order relational reasoning, or the eduction of correlates, was widely assumed to be absent before the

Piagetian stage of formal operations, a stage normally reached at around 12 years of age. However, recent work by Gentner (1977) and by Holyoak et al. (1984) suggested that the education of correlates may occur earlier than this.

It is clear that the major thrust of the work reviewed in Chapter 2 would not lead one to expect young children to use analogies in the earliest stages of learning to read, at around the age of 5-7 years. However, as also shown in chapter 2, the conclusions reached in many of these studies were open to alternative interpretations. Thus, a careful review of the literature on children's ability to reason analogically leaves open the question of whether 5-7 year old children are capable of using analogies to help them to read and spell new words.

3.5.ii. The cognitive-developmental viewpoint and analogies in reading and spelling

Let us now consider whether the kinds of analogies being examined by Piaget, Sternberg, etc. are the same as the kinds of analogies which Marsh et al. and Baron are examining anyway. It is possible that young children might successfully use 'analogies' to read and spell new words simply because analogical reasoning per se is not involved. This would then explain why analogies may be found in reading and spelling long before they are found in other areas of cognition.

To consider this question, Baron's (1979) example of reading 'yave' by analogy to 'gave' will again be examined. This can be stated formally as 'the letter string 'GAVE' is related to the pronunciation /gev/ as the letter string 'YAVE' is related to the

pronunciation /yev/', or 'GAVE:/gev/::YAVE:/yev/'. Let us now apply Sternberg's analysis to this analogy. Sternberg argued that three mental steps were necessary to account for the process of first- and second-order relations in the solution of analogies. These were inferring the relation between the a and x terms, mapping the relation between the a and b terms, and applying the analogous relation to the relation between the a and x term to the b term in order to solve the analogy.

Firstly, therefore, a relation must be inferred between GAVE and /gev/. The obvious relation is that /gev/ is the spoken form of the written letter string G-A-V-E. Secondly, a relation must be mapped between GAVE and YAVE. The relation here is that both letter strings are identical apart from the initial letter. This step involves segmentation and chunking, as the child must segment /gev/ into /g/ + /ev/, giving 'G-AVE:/g/-/ev/::Y-AVE:/?/'. Finally, an analogous relation to that inferred for GAVE:/gev/ must be applied to YAVE. The analogous relation is that the spoken form of the letter string GAVE must be similar to the spoken form of the letter string YAVE, apart from the first letter. So completing the analogy, we get: 'G-AVE:/g/-/ev/::Y-AVE:/?/-/ev/'. All that is now required is a pronunciation for the non-analogous letter 'Y', and the full pronunciation for the unknown word can be established.

3.5.iii. Are analogies in reading and spelling 'true' analogies?

While the child still requires extra knowledge to complete the pronunciation for the unknown term (i.e. the phonology for 'Y', which is not contained within the terms of the analogy itself), the analogical comparison as such seems perfectly valid. The problem of deriving the phonology for the extra letter ('Y') is separate from

the question of whether analogical reasoning is used, and seems comparable to the fact that extra semantic knowledge is required to complete an analogy such as 'high:low::wide:?'. Thus in spite of the fact that extra knowledge is required in order to complete the orthographic analogy, it seems clear that analogical reasoning should be involved.

Another test of whether orthographic analogies actually involve analogical reasoning would be to consider whether orthographic analogies can be reversed in the way that standard analogies can. Analogies involve an equality of proportions, and so an analogy like 'a:x::b:y' can also be expressed as 'a:b::x:y'. Using our analogy 'GAVE:/gev/::YAVE:/yev/', we can reverse this analogy to give 'GAVE:YAVE::/gev//yev/'. This expresses the fact that one spelling pattern is related to a similar spelling pattern in the same way as one pronunciation is related to a rhyming pronunciation, that is, that they are similar in all respects except for the representation of the initial letter/sound. So this is also a perfectly valid analogy. Again, it seems that we are justified in saying that an orthographic analogy involves analogical reasoning.

However, the necessity for extra knowledge in solving orthographic analogies suggests that, at the very least, knowledge of more than one analogous word is needed to read a new word by analogy. In the case of 'yave', knowing the words 'gave' and 'yes' would in theory be enough to synthesise a pronunciation for 'yave' by analogy, given possession of the component skills outlined previously. The analogy 'YES:/yes/::YAVE:?' requires slightly different categorisation, segmentation and chunking skills, as this time the child must make an analogy between the beginnings rather than between

the ends of the words. Alternatively, analogy could be combined with individual letter-sound knowledge, so that analogy could be used to read the rime of the word (e.g. '-ave'), while individual grapheme-phoneme correspondence knowledge could provide the pronunciation for the onset ('y').

In order to use analogy, the child clearly also has to have a lot of (perhaps implicit) specific knowledge about the reading process. This includes knowledge that words which look similar often sound similar; that in the case of letter strings which differ only in their initial consonants, this similarity is usually one of rhyme; that detachment of the initial phoneme(s) (the onset) of rhyming words isolates the common sound segment; and that combination of the sound of the initial letter(s) of the unknown word with this common sound will yield the pronunciation of the novel letter string. In other words, if a child uses analogy in reading and spelling, this demonstrates an understanding that words which are spelled the same often sound similar, while words which sound similar are often represented by similar orthographic sequences. This understanding is based on reasoning about relationships, which is exactly the 'eduction of correlates' defined by Spearman. The fact that some extra reading knowledge is required in order to arrive at a final answer does not change the fact that analogies are probably being made.

III.5.iv. Conclusion

Having established that analogical reasoning per se and the use of analogies in reading and spelling are formally similar, we will now consider work on the development of the component skills required for making analogies from known to new words. It has already been

mentioned in Chapter 1.4 that analogy requires the ability to categorise words orthographically and phonologically, to chunk together the letters in a word relevant to the analogy, to segment this chunk from the rest of the word, and to blend this chunk with the phonology corresponding to the non-analogical part of the new word. These skills will be considered in the next chapter.

CHAPTER FOUR

THE COMPONENT SKILLS REQUIRED FOR ANALOGY

4.1. Introduction

Children require more than simply the ability to reason analogically to make analogies in reading and spelling. They must also have a number of component skills available, skills which are specific to dealing with written language. This point has been implicitly recognised by other authors, who have placed analogy at the final stage of reading development (Marsh and Desberg, 1983; Frith, 1985). These authors agree that use of an analogy strategy in reading depends on the acquisition of a sight vocabulary, and on the learning of grapheme-phoneme correspondences. The acquisition of these skills is held to constitute separate and earlier stages in the development of reading. Marsh and Desberg call these earlier stages 'rote learning' and 'combinatorial rule', Frith refers to them as 'logographic' and 'alphabetic'.

For both these authors, the most sophisticated stage, and the last to emerge, is the stage at which orthographic analogies are used to read new words. Both Marsh and Desberg, and Frith, suggest that a similar sequence of stages (rote learning, grapheme-phoneme knowledge and then analogy) also occur in the development of spelling. Marsh and Desberg suggest that the same sequence of stages is passed through as in reading development, but much more slowly: "We have found that the analogy strategy in spelling develops much more slowly than the analogy strategy in reading". (p. 153). Frith suggests that the stages may be concurrent, but out of phase, so that a child who

is at the alphabetic stage in reading may be at the logographic stage in spelling. However, both these stage models concur in placing the use of an analogy strategy at the final stage of development, and so equating the use of analogy with skilled or fully-developed reading and spelling.

These models fit evidence which suggests that adult or skilled reading may operate via analogy (e.g. Glushko, 1979). However, according to these models, analogical skills are not important for the development of reading and spelling. This alternative possibility is examined in this thesis. While the use of analogy in reading and spelling may well require the possession of the various component skills implicit in the above models and detailed in the introduction, such as rhyming and segmentation abilities, this need not imply that a complete acquisition of such skills must precede the use of analogy.

Instead, it is equally possible that the use of analogy in reading and spelling may itself help to develop some of those skills which are important for its use. For example, generalising from one word to another on the basis of spelling and sound may enhance categorisation skills, since while analogies such as 'beak-peak' and 'beak-weak' are valid, an analogy such as 'beak-break' is not. Experience with ambiguities of spelling-sound correspondence, such as 'peak-weak-break', may help a child to realise that similarity of spelling does not necessarily imply similarity of sound, and so result in 'break' being categorised differently from 'peak' and 'weak'. Similarly, generalisation may enhance segmentation skills, since an analogy like 'seat-cheat' may help a child to realise that two letters ('ch') can represent a single sound (č).

It could even be argued that it is more plausible to think of analogy as operating in the early rather than in the final stages of reading and spelling development. Children may be more willing to generalise on the basis of spelling and sound before they become aware that English orthography has multiple orthographic representations for single sounds (e.g. 'church', 'birch', 'search', 'perch'...), and similarly that an orthographic unit can have many pronunciations (e.g. '-ove' in 'love', 'rove', 'move').

As discussed in Chapter 1.4, to read an unknown word like 'yave' by making an analogy, the child must first select an appropriate word to form the basis of the analogy (e.g. 'gave'), which requires graphemic categorisation skills. To use the chosen word to read the unknown word, the child must possess chunking and segmentation skills, since the child must be able to chunk together the rime of the word, and then isolate this via segmentation to find the phonology of the orthographic sequence relevant to the analogy. This must require knowledge of rhyme and alliteration, as the phonological relationship for an analogy like 'gave:yave' is one of rhyme, while the relationship for an analogy like 'beak:bean' is one resembling alliteration. The child also requires some knowledge of individual letter-sound correspondences, as a phonological representation for the non-analogous part of the word is also required. Finally, the child must be able to blend together the sounds of the onset and rime of the unknown word in order to read it aloud (e.g. /y/ + /ev/ -> 'yave').

The overall question of this chapter is then whether children have the component skills important for the use of analogies in reading and spelling available before they start learning to read.

This question will be considered in turn for the skills of categorisation, chunking, rhyming, segmentation, and blending. This chapter will not include studies of these skills which have been carried out solely on backward readers, however, as these are not strictly relevant to the issues being considered.

4.2. Categorisation

As shown in Chapter 1, categorisation is an important skill for the use of analogies in reading and spelling. To make an analogy in reading, a child has to categorise words as being similar in spelling pattern, as a known word with a similar spelling pattern to the unknown word must be selected to form a valid analogy (e.g. gave-yave). This requires orthographic categorisation skills. Similarly, to make an analogy in spelling, a child has to categorise words on the basis of sound, since a word which sounds similar to the unknown word must be chosen to form the analogy. This requires phonological categorisation skills. A special kind of phonological categorisation involves rhyming and alliteration. As these skills are very important for the development of reading as well as spelling, they will be discussed separately in section 4.4.

4.2.i. Orthographic categorisation

One of the few studies relevant to the orthographic categorisation skills of young children was carried out by Santa (1977). She asked 7 and 10 year old readers to perform a same-different task, in which a written upper-case word was presented along with a pair of letters which either were or were not part of the word (e.g. BLAST:BL or BLAST:LE). Santa varied the position of the subset of letters used, so that all parts of the five-letter

words were covered. She found that the initial consonant cluster was recognised significantly faster than all the other parts of the word as reading level improved. The 10 year olds were significantly faster at this than at recognising single letters and other units, whereas the 7 year olds showed no differences in reaction time between the initial and final consonant clusters. Both groups of children were slowest of all at recognising letters from the middle of the words (BLAST:AS).

Santa concluded that orthographic judgements were affected by letter position and by reading level. However, as she did not check whether the 7 year olds could read the words being used, it is not clear whether there is differential orthographic processing as reading improves. Instead, the differences in performance could simply have been due to the 10 year olds being able to read the words which were used.

To remedy this, Santa went on to perform a second experiment in which she checked in advance that the children could read all the words being used. 7 and 10 year old readers performed a same-different task with picture-word pairs, and had to respond 'same' if the word correctly named the picture. The words were presented in lower case with gaps which either violated or preserved spelling pattern boundaries (c-hild, ch-ild, chi-ld, chil-d). Santa found that the 7 year olds were significantly slower on the 'same' judgements for words with gaps which violated spelling pattern boundaries (b-last, bla-st, blas-t). Performance on words divided into onset and rime (bl-ast) was as fast as that for words presented without gaps (blast). The 10 year old readers were equally fast on all the different stimuli. This result suggests that when the 7 year

olds can read the words being used, they also demonstrate superior recognition of the initial consonant cluster compared to other subword units. However, it can also be interpreted as showing that younger readers are faster at recognising words when visual distortions preserve the onset-rime boundary. As the 10 year olds were at ceiling on the task, we cannot tell whether this is a developmental effect. However, it is clear that young children's visual categorisation skills are quite sophisticated.

This result is obviously an important one for an analogies hypothesis, as the division of words at the onset-rime boundary is necessary for making analogies between the ends of words. The demonstration that young children make such divisions with ease means that the kind of orthographic categorisation required for analogies between the ends of words is a skill which is available early in the reading process. Without information about younger children, however, we cannot tell whether it is available before reading commences.

4.2.ii. Orthographic and phonological categorisation

Pick, Unze, Brownell, Drozdal and Hopmann, (1978), looked at the way in which children categorised words which were presented either auditorily or visually. They asked children aged 7, 9 and 11 years to judge which pairs of words were more alike, the children either being shown the written words or listening to the experimenter pronounce them. The word pairs were either alike at the beginnings (e.g. bum-bug, slot-slap, buck-bust), or at the ends (hop-pop, drip-chip, land-mend).

Pick et al. found that for visual judgements, the 7 year olds judged the word pairs which began with the same letters as more

alike, while the 9 and 11 year olds judged the words which ended with the same letters as more alike. For the auditory judgements, children judged the words which ended with the same letters as more alike at all ages. Thus in tests of phonological categorisation children seem to prefer judgements based on rhyme or shared final consonants at all ages. For graphemic categorisation, there seems to be a developmental shift from judging on the basis of shared initial orthography to shared final orthography. However, as Pick et al. did not check whether the children could read the words being used, this latter conclusion can only be tentative. It is possible that the 7 year olds were matching on the basis of shared initial orthography in the visual condition purely because they could not read the words, and not because of any differences in processing words in reading.

Evidence for orthographic and phonological categorisation also comes from an experiment by Condry, McMahon-Rideout and Levy, (1979), which compared the two. These authors asked children aged 7 and 10 years and college students to make same/different decisions on the basis of either similar orthography (roam-room), or similar sound (ear-here). The subjects had to decide which of two visually presented words sounded or looked the same as a visually presented target word. The incorrect choice word could also be visually or phonologically similar to the target word, depending on the condition. Hence for the orthographic judgement ('looks like'), the distractor could be phonologically similar to the target (chair: chain, dare), whereas for the phonological judgement ('sounds like'), the distractor could be visually similar to the target (dry: lie, day). The effect of these distractors was compared to control distractors which were neither visually nor phonologically similar to the target word (eyes: size, room).

Condry et al. found that the orthographic judgements were significantly faster than the phonological judgements at all ages, with an especially strong effect at 7 years. This suggests that children are very good at categorising words on the basis of spelling. The subjects were also good at categorising words on the basis of sound, but were much slower at this task, even at adult level. It is not clear whether they were slower at the rhyming judgements because they had to access phonology from the written stimulus to make the sound judgement (presentation was visual only), or whether they were slower because the orthography of the rhyming pairs differed, and this had an inhibitory effect. A condition where orthography and phonology both match would be required to sort out this question (e.g. chair: hair, room). If the different orthography was having an inhibitory effect on the rhyme decisions, subjects should be faster at saying that 'chair' and 'hair' rhyme than at saying that 'chair' and 'dare' rhyme; whereas if orthography was not having an inhibitory effect they should perform as fast on 'chair-hair' as on 'chair-dare'.

The effect of the different distractor stimuli suggests that the inhibition explanation may be the right one. Condry et al. found that the influence of the orthographic distractors on the phonological judgements was strong at all ages (compared to the control distractors), whereas there was no influence of the rhyming distractors on the orthographic judgements at any age. This suggests that when presentation is visual, children are strongly influenced by spelling in making phonological decisions. They expect words which are spelled the same to sound the same, and so are distracted by similar-looking words which do not actually rhyme with the target word. A condition involving similar orthography and phonology would

have been useful in checking this interpretation. However, two other experiments have compared the effects of similar and dissimilar orthography on phonological judgements. These studies are by Steinhauser and Guthrie, (1978), and Rack, (1985).

4.2.iii. Links between orthographic and phonological categorisation

Steinhauser and Guthrie asked children aged 7 and 10 years to make same/different decisions about pairs of words which either rhymed and were orthographically similar (heat-beat), rhymed but were orthographically dissimilar (heat-feet), did not rhyme but were orthographically similar (heat-head), or differed in both orthography and phonology (heat-said). Presentation was visual, and the children were either required to make orthographic categorisation decisions or phonological categorisation decisions.

Steinhauser and Guthrie found that orthographic judgements were consistently very good, with performance ranging from 90-95% correct at both ages, and with no significant differences between tasks. Both age groups made more errors when a phonological judgement was required, however. The children were especially bad at making phonological judgements when orthography and phonology conflicted, saying that such pairs (e.g. 'heat-feet') did not rhyme on 24.6% of trials at age 7, and 18% of trials at age 10. If orthography and phonology agreed (e.g. heat-beat), errors fell to 10% and 14% respectively. Similarly, the children said that pairs like 'heat-head' did rhyme on 21.4% of trials at age 7, and 18% of trials at age 10, compared to 10.5% and 9.6% errors on pairs like 'heat-said' respectively. These results suggest that children expect words which are spelled the same to sound the same and vice versa, as they make more errors when these expectations are violated than when

they are not. However, the strength of this effect seems to decline with age, as the 7 year olds showed much stronger effects than the 10 year olds. One possibility is that this decline occurs because increasing experience with English orthography teaches children that spelling and sound do not always agree.

Rack (1985) used a similar design in an experiment with 10 year olds. He asked the children to make rhyme decisions about visually presented word pairs, and then gave them a visual cued recall task using one of the words from the pairs. The word pairs either rhymed and were orthographically similar (farm-harm), rhymed but were orthographically dissimilar (farm-calm), did not rhyme but were orthographically similar (farm-warm), or differed in both orthography and phonology (farm-sand).

He also found that more errors in judging rhyme were made for the pairs where orthography matched but the words did not rhyme (farm-warm) than for any of the other pairs, although the differences were not significant. In the recall task, there was a significant effect of orthography, with orthographically similar words recalled better than orthographically dissimilar words, and a significant effect of rhyme, with rhyming words remembered better than non-rhyming words. There was no effect of orthographic similarity for cued recall with auditory presentation, however, whereas the effect of phonological similarity remained significant. Again, the results suggest that children can categorise words on both an orthographic and a phonological basis, and tend to perform best when orthography and phonology agree. This suggests that children expect similar orthography to predict similar sound.

4.2.iv. Categorisation in preschoolers

Turning now to younger children, there is very little work on the categorisation skills of pre-schoolers with respect to written language. One study that has been done is that of Skjelfjord (1976), on phonemic categorisation. Skjelfjord looked at the phonemic categorisation skills of 24 preschoolers (5-6 years old) in Norway. He was interested in whether the children could segment words, and whether the segments could be grouped to form categories. The children were taught individually to analyse words, and their reactions during training were closely observed to find out how they set about the task. Training consisted of telling the children to "listen out" the sounds in the words, and to try and "feel in the mouth" how the word was produced, thus highlighting both acoustic and articulatory information. Short stories were used to stress individual phonemes, and pictures of things and events illustrating the given phoneme in an initial, medial or final position were also used.

Training lasted for 22 weeks, during which all 27 Norwegian phonemes were taught in daily sessions. The children were asked to find each phoneme in initial, medial and final positions in single-syllable words, and untaught phonemes were included to test for transfer. Performance was compared to a pretest given before training started, which asked for the initial sound in 26 words.

Skjelfjord found that half of the children's responses showed no analytical ability at all at pretest, while a further 15% only showed analysis of words into syllables. Analysis into phonemic units improved quickly following training, however, increasing to 63% of responses after one week, and 77% of responses after two weeks. Even

so, at first the phonemic unit reported was frequently not the one requested (i.e. initial, medial or final), usually being the vowel sound in a given word. Only in the later stages of training, when most children had adopted an articulatory technique for performing the task, were children able to produce the specific phoneme requested.

Skjelfjord also looked at children's phonemic categorisation skills during training. He argued that active categorisation was shown by the tendency of some children to segment a word correctly and then report a sound similar to the one in the position asked for, but not part of the word itself. Presumably the children categorised the phonemes as very similar, and so reported one sound in place of the other. For example, one child first uttered all the sounds in a given word correctly, then repeated the sound in the given position correctly once more, and eventually reported a phonetically similar sound. Thus even 5 year old children categorise phonemes according to phonetic similarities and differences.

This conclusion is also supported by the work of Read (1971) on the spontaneous spelling performance of 4-5 year old Harvard nursery children. These children's representations of certain sounds in words provided clear evidence of phonemic categorisation. For example, Read was able to show that the children perceived the /t/ in 'truck' as more similar to the /t̪/ in 'chicken' than to the /t/ in 'top', as they spelled 'truck' and 'chicken' with the same initial letter. Thus children actively categorise words as having common phonemes, but these categorisations do not always agree with those used by adults.

4.2.v. Conclusions

The evidence reviewed above shows that children have good phonemic, orthographic and phonological categorisation skills from an early age, and also have strong expectations about the relationship between spelling and sound. Such expectations might underly the use of analogy in reading and spelling, since analogy depends on using spelling to predict sound and sound to predict spelling.

However, successful use of analogy also requires the ability to chunk words into the units which are relevant to the analogy. Segmentation skills of this kind have been studied by Helfgott (1976), and by Treiman (1985), who have looked at chunking abilities in tasks involving both segmentation and blending.

4.3. Chunking

To make an analogy between 'beak' and 'weak', the words must be parsed into onset (initial consonant(s)), and rime (vowel cluster and terminal consonant(s)). Some evidence reviewed in section 4.2.i. suggested that such chunking comes easily to children if orthographic categorisation is the task under examination. We will now examine chunking skills when words are presented orally.

4.3.i. Chunking CVC stimuli

Helfgott was interested in the relationship of syllabic structure to segmentation and blending skills. She suggested that the division of a syllable into CV-C may be more natural than division into C-VC, as the CV unit appears first in infant babbling, and as a consonant preceeding a vowel is co-articulated with the vowel to a greater extent than is a consonant following a vowel. She argued that

if chunking a consonant-vowel-consonant (CVC) syllable into CV-C was easier than chunking it into C-VC, then this would have important consequences for the teaching of segmentation and blending skills.

To examine this question, Helfgott took 103 kindergarteners and split them into six groups matched for chronological age, mental age, and scores on the Wepman Auditory Discrimination Test (Form II). This test measures auditory discrimination by asking children whether nonsense syllables differing by one phoneme are the same or different. The groups were given segmentation and blending tasks, involving the segmentation of CVC words into either CV-C, C-VC, or C-V-C (e.g. like segmenting /kaet/ into either /kae/-/t/, /k/-/aet/, or /k/-/ae/-/t/), or the blending of these units into words. Three groups got the segmentation task first and three groups got the blending task first. In addition, a control group received the CVC words in a sentence production task. The segmentation task used the Elkonin (1973) method of replacing each phonemic segment within a word by a counter (see section 4.5.), a picture of the word being provided as an aid to memory. In the blending task, the experimenter spoke the segments to be blended aloud while placing a counter for each segment in front of the child. If the child blended the segments together correctly, the picture of the word was produced as a reward.

Forty test words were given daily for a four-day period, with feedback being given on each trial. This introduced a training element into the experiment. On the fifth day of the experiment, the Wepman test (Form I) was given as a post-test. In addition, the children were followed up a year later in first grade, and their reading was tested using the Wide Range Achievement reading test.

Helfgott found that the C-V-C task was significantly harder than

either the CV-C task or the C-VC task for both segmentation and blending. Comparing the CV-C and the C-VC stimuli, children found it significantly easier to segment words into C-VC than into CV-C, but in contrast found it significantly easier to blend CV-C units together than C-VC units. This pattern of results was supported by the number of kindergarteners able to perform each task. Over a third were unable to segment more than 25% of the C-V-C stimuli, compared to 11% of children for the C-VC stimuli and 7% for the CV-C stimuli. Similarly, 12% were unable to blend more than 25% of the C-V-C stimuli, whereas no children blended less than 25% of either the C-VC or the CV-C stimuli. The easiest task for the kindergarteners was to blend CV-C stimuli: around 90% of children were able to blend between 76-100% of the stimuli. Finally, training on segmentation and blending did not significantly improve Wepman performance at post-test, but this is unsurprising given the short training period (four days).

Helfgott explained the blending results in terms of the natural structure of the syllable, arguing that the greater ease of blending the CV-C stimuli was accounted for by the co-articulation of initial C and following V. She argued that the segmentation results (C-VC segmentation easiest) were due to some prior training during the school year on identifying initial consonants in words, and on rhyming. However, if this was the case, it is not clear why prior training on initial consonants did not similarly facilitate C-VC blending.

Helfgott also looked at the predictive value of segmentation and blending skills for subsequent performance on the Wide Range Achievement Test of reading. She found that segmentation skills were

a significant predictor of reading achievement, accounting for 52% of the variance in WRAT scores. Blending scores did not account for a significant additional portion of the variance, even though they correlated 0.49 with later reading scores.

Helfgott's differential results for CV-C and C-VC segmentation and blending suggest that it is easier to chunk words into initial C and following VC (onset and rime) in segmentation, but that it is easier to blend CV chunks to a final C than to blend initial Cs to a final VC chunk. However, her position that the CV-C division of the syllable is more natural has been challenged by Treiman (1983), who argued from linguistic theory that the natural units of the syllable were the onset and rime.

Treiman (1985) gave children a word game in which segmentation and blending skills were confounded. Children aged 8 years were asked to transform auditorily-presented CVC syllables via phoneme substitution, either by replacing the first two phonemes with two new phonemes (joot-lut, fog-lug), which requires both CV-C segmentation and blending, or by replacing the last two phonemes by two new phonemes (joot-jul, fog-ful), which requires both C-VC segmentation and blending. Treiman predicted that the C-VC task should be easier than the CV-C task, as the former required a division between onset and rime, whereas the latter required the initial CV to be subtracted as a unit. In a second condition, children were given CCV syllables to transform in the same way (fru-slu, brai-slai; or fru-fli, brai-bli). This time the pattern of predictions was reversed, as the initial CC constituted the onset, and so substituting for the first two phonemes should be easier (fru-slu).

Both predictions were confirmed. The children were much better

at learning the word games which treated the onsets and rimes as units than at learning the games which did not. Treiman went on to show that these results extended to 4 and 5 year old children, who were better at recognising a spoken (or written) consonant target when it constituted the onset of a word than when it was the first phoneme of a consonant cluster (e.g. s-sink was easier than s-snake). Treiman concluded that in analysing spoken words the division between onset and rime is the most natural one.

However, as Treiman's task involved simultaneous segmentation and blending of either CV-C or C-VC stimuli, it is impossible to tell how much of the superior performance with the C-VC (or CC-V) divisions was due to the segmentation component of the tasks. Helfgott showed that while C-VC segmentation was easier than CV-C segmentation, the reverse was true for blending. It seems possible that segmentation effects were overriding blending effects in Treiman's task, but this question cannot be answered without either including separate blending and segmentation conditions, or alternatively including a C-VC segmentation + CV-C blending task and a CV-C segmentation + C-VC blending task. If Helfgott's finding that CV-C blending is easier is correct, then children should be superior at a task involving C-VC segmentation and CV-C blending than on Treiman's C-VC segmentation and blending task.

Finally, it would be interesting to repeat Treiman's experiment on Helfgott's age group (5 year olds). Treiman's results for 4 and 5 year olds are based on a much easier task (consonant recognition) than the word game used with the 8 year olds, and so she may find developmental differences here. However, as far as the chunking skills required for analogy are concerned, both these experiments

together suggest that children can both segment words into either C-VC or CV-C units, and also blend such units into words.

4.3.ii. CVC chunking and reading

If the parsing units which are natural in auditory segmentation are also natural in segmenting written words, clusters of letters which preserve either onset or rime should be extracted more easily from printed stimuli than clusters of letters which violate the onset-rime division. An experiment by Pick (1978) does not support this hypothesis, however.

Pick taught kindergarteners to read 12 CVC words by rote (e.g. bum, hum, rat, ran). The children were then given new words to read of three types (all nonsense words): 1. same initial (CV) segment (e.g. hun, rad); 2. same final (VC) segment (e.g. fum, lat); and 3. words made up of letters from the training words which did not preserve VC or CV segments (e.g. bap, fud). Treiman's hypothesis would predict that children should be best at reading words of the second type, where the rime of each trained word is preserved. However, Pick found that the children were significantly better at reading the type (1) words at transfer than they were at reading both the type (2) and the type (3) words.

Pick claimed that the children were abstracting CV units from the training words, and were using these to help decode the transfer words. To support this hypothesis, Pick showed that most errors on the type 1 words were due to misreading of the final consonant. Children tended to assign phonology correctly to the initial CV, but then to mispronounce the final consonant. Taking errors on all word types, Pick found that the initial segment was read correctly on 26

occasions, while the final (VC) segment was only read correctly on 10 occasions. From this, Pick concluded that children were better at abstracting the initial segments in words than at abstracting the final segments.

This conclusion would not be predicted by Treiman's work on natural parsing units, which would predict that the final segments in words should be the easiest to abstract. One explanation for the different results could be that Pick's task was visual, while Treiman's was auditory. Onset and rime divisions could be more natural in auditory tasks than in visual tasks. However, if blending is a more important component of early reading than segmentation, then Helfgott's results would predict superior performance on the type I words, as blending a known CV to a new final C should be easier than blending a new C to a known final VC.

An alternative explanation of Pick's results could be that the superior performance on the type I words was caused by the facilitative effect of a shared initial consonant. It is well-documented that children find the first letter in words the easiest to sound out (e.g. Fowler, Liberman, and Shankweiler, 1977). Thus Pick should also have had a condition where only the first consonant was similar to the training words (e.g. hig, rud). This would have enabled the effect of shared initial consonant to be compared to that of shared initial CV.

Finally, it is possible that Pick's results were partly due to the regularity of her CVC stimuli. If the onset-rime division had been tested with longer single-syllable words (e.g. 'beak'), then C-VVC transfer may have proved to be easier than CVV-C transfer, as Treiman would predict. The best conclusion that can be drawn at

present is that chunking words into onset and rime is more natural in an auditory task than in a visual one. The role of the segmentation and blending components of both Treiman's and Pick's tasks remains to be elucidated.

4.3.iii. Conclusions

The experiments reviewed above suggest that children can chunk CVC stimuli into both CV-C and C-VC depending on the task. The relationship of such chunking skills to reading, however, is unclear. It remains to be seen whether CV- or -VC units are abstracted best when using known words to read new words.

Making divisions between onset and rime is important for rhyming, however, as words which rhyme have identical rimes. Rhyming skills seem to play an important role in the development of reading and spelling, even though rhyming is an auditory task. Work on children's rhyming and alliteration skills will now be considered.

4.4. Rhyming

Rhyming is a special case of phonological categorisation. Recognising that words like 'cat', 'mat', and 'hat' rhyme involves categorising words together on the basis of common sounds. Such phonological categorisation is very important for making analogies in reading. Words which rhyme often have common spelling patterns as well, and these common spelling patterns can form the basis for making a prediction about common sounds through making an analogy. We will now examine whether children are able to form such rhyming categories before they learn to read.

4.4.i. Rhyming in forced-choice tasks

There is growing evidence that young children are skilled at recognising rhyme before they learn to read. A study by Knafle (1974) showed that even kindergarteners (age 5) can distinguish rhyming words under certain conditions. She gave 273 children aged from 5 to 8 years a choice recognition task, in which the children had to say which of two CVCC words rhymed with a given target word. For example, the children were asked "Which word rhymes with 'belt': 'best' or 'felt'?". The distractors either differed from the target in the second (belt: best, felt) or final consonant (park: part, mark). To control for choices based on the initial consonant, Knafle also gave choice pairs which began with the same letter (e.g. silk: milk, mink; and yard: hard, harm).

The kindergarteners performed correctly on 75% of the trials, while the 8 year olds performed at around 90% correct. All children found the pairs where the distractor differed in the second consonant (belt: felt, best) significantly easier than the pairs where the distractor differed in the final consonant (park: mark, part), the 5 year olds scoring at chance on the latter. The 5 year olds also found the final consonant pairs harder in the same initial letter condition (yard: hard, harm); however, both types of stimuli where the initial consonant was kept constant were significantly easier at all ages. This suggests that 5 year olds can distinguish rhyme even when the choice pairs only differ in one phoneme. However, if a distinction must be made between two words which only differ from the target in either initial or final consonant, then the youngest children perform at chance. This may not have been the case if CVC stimuli had also been used, however.

Lenel and Cantor (1981) gave children aged 4, 5 and 6 years a rhyme recognition task similar to that used by Knafle. The children were given a target word (e.g. 'bed'), and were asked to indicate which one of two subsequently presented choice words rhymed with the target. The choice pairs varied in the number of phonemes which the incorrect word had in common with the target, ranging from none ('bed': 'sled', 'ring') to a difference of one phoneme only ('mouse': 'house', 'mouth'). Lenel and Cantor found that the children were very good at recognising rhyme. The 4 year olds performed correctly on 76.9% of trials, the 5 year olds on 83.4% of trials, and the 6 year olds on 86.6% of trials. Choice pairs with the same number of shared phonemes were the most difficult, as would be expected. However, even the youngest children were extremely successful at making rhyme decisions in this task.

An experiment by Read (1978) provides further evidence that young children are very good at categorising words on the basis of rhyme. He asked 5 year old children to play a rhyming game in which they had to decide which words various puppets 'would like'. The puppets liked words which rhymed with their names, so the children had to decide whether Ed would like 'bed' or 'bead', 'food' or 'fed', and so on. Read found that the children were very good at recognising which words the puppets would like, 82% of children easily reaching criterion on the rhyming task. Again, this study shows that even kindergarteners are skilled at making judgements on the basis of rhyme.

4.4.ii. Rhyming and alliteration in an oddity task

The only authors who have looked at categorisation on the basis of alliteration as well as rhyme are Bradley and Bryant (1978, 1983).

They looked at rhyming and alliteration skills via a test of auditory organisation. This test required children to select the 'odd man out' of sets of 3 or 4 words, presented auditorily. The 'odd man out' either differed in initial sound (rot, rod, rock, box), medial sound (pop, hop, tap, lop), or final sound (fan, cat, hat, mat). Bradley and Bryant showed that children aged 4 and 5 years found categorisation on the basis of medial and final sounds (rhyme) easier than categorisation on the basis of initial sound (alliteration). The children's scores on all types of categorisation were well above chance, however, showing that young children are very good at categorising words on the basis of their sounds before they start learning to read.

There is increasing evidence that rhyming ability may be very important for the development of reading. A number of studies, reviewed below, have suggested the existence of a causal link between rhyming skill and later progress in reading.

4.4.iii. Rhyming skills and later reading development: Longitudinal studies

Lundberg, Olofsson and Wall, (1980), used path analysis to determine the relationship between a number of different metalinguistic tasks and the progress made in reading and spelling by 143 children in Sweden. They first saw the children in kindergarten, before they learned to read and spell. At this stage, the children were given tasks involving word synthesis (blending syllables and phonemes), word analysis (segmentation into syllables and phonemes), and rhyme production. Reading level was also assessed, on a scale from 0 to 4. The children were then followed up after one and two years schooling (grades 1 and 2), and the correlations between the

metalinguistic measures taken at kindergarten and reading and spelling levels at grades 1 and 2 were calculated. A causal model linking the metalinguistic skills to reading and spelling development was postulated, and tested via path analysis.

Lundberg et al. found that the only significant determinants of reading ability in grade 2 were the ability to produce rhymes, and the ability to analyse phonemes and to reverse their order. The latter was also a significant predictor of later spelling ability. Thus rhyming skills at kindergarten can significantly determine reading development at grade 2. However, this relationship is only a correlational one, and so the possibility that the connection arose from the action of an uncontrolled third variable cannot be ruled out. This third variable could determine both rhyming skill and reading skill, and so lead to an apparently causal relationship between the two. However, given the comprehensive nature of the design, which controlled for variables such as IQ and verbal ability, such an explanation of the results is unlikely.

In a similarly large-scale, longitudinal study, Bradley and Bryant (1983) examined the relationship between children's skills on their test of auditory organisation and later reading ability. They gave 104 4 year olds and 264 5 year olds the odd man out test before the children began school, and then measured their reading and spelling performance three years later. Stepwise multiple regressions showed that the relationship between performance on the auditory organisation test and later achievement in reading and spelling was highly significant, even after IQ and memory were partialled out.

A recent study by Ellis and Large (1986) examined the relationship between a number of metalinguistic tasks, including the

Bradley and Bryant test of auditory organisation, and the reading and spelling development of 40 children over a three year period. The children were first seen at age 5, and then at yearly intervals until age 8. The metalinguistic tasks were given at each yearly follow-up. At age 8, three groups of five children were selected, who were respectively of high IQ but poor reading (group A), of high IQ and good reading (group B), and of low IQ and poor reading (group C). Ellis and Large then compared the patterns of development for these three groups, by comparing their performance on the different metalinguistic tasks over the three years of the study.

Looking first at groups A and B, the most important measure in discriminating between the two groups turned out to be Bradley and Bryant's rhyme sub-test (final sound different). Group B children were significantly better at this test than group A children, in spite of the fact that group A were matched with group B in intelligence. The second most important discriminator was a test of rhyme production. Thus differences in rhyming ability seem to be the most important distinguishing factor between good and poor readers who are matched for IQ. This suggests that rhyming ability is an important determinant of later reading development.

For groups A and C, where both groups were equally poor at reading, but differed in IQ, the relationship with rhyme again assumed prime importance. This time it was the tests associated with IQ which discriminated between the two groups, and the tests associated with reading development which did not. The tests which turned out to be most strongly related to reading were rhyme production and Bradley and Bryant's rhyme sub-test. So again, rhyming skill was shown to play a key role in the later development of

reading. Finally, the comparison between groups B and C (good reading, high IQ, and poor reading, low IQ) again showed performance on Bradley and Bryant's rhyme sub-test to be the most important discriminator. Thus the importance of rhyming skills was strongly maintained across all three group comparisons.

4.4.iv. Rhyming skills and later reading development: Training studies

Bradley and Bryant also included a training component in their large-scale longitudinal study (Bradley and Bryant, 1983). To check that the relationship between categorising sounds and reading and spelling development was causal rather than simply correlational, 65 of the children were trained on sound categorisation for two years of the study. These 65 children all had very low initial scores on the sound categorisation task (two standard deviations below the mean), and could not read when training began. The children were split into four groups. Group I received training on sound categorisation using pictures of simple objects, for example 'hen', 'hat' (beginning sound), 'hen', 'pet' (middle sound), 'hen', 'man' (final sound). Group II received similar training, but were also taught how each sound was represented alphabetically using plastic letters. Groups III and IV were control groups. Group III received training with the same pictures as groups I and II, but were taught to group the pictures semantically (e.g. 'hen', 'bat': animals). Group IV received no training at all.

Bradley and Bryant found that training in sound categorisation had a strong effect on reading and spelling development, but not on other areas of intellectual development, such as mathematics. Groups I and II were four months and eight months ahead of group III in

reading, and four months and 17 months ahead in spelling, respectively, although these differences were only significant in the case of group II. However, both groups I and II were significantly ahead of group IV, the unseen control group, the differences being eight and 12 months in reading, and 10 and 23 months in spelling (using the Schonell test).

The results of this training study in conjunction with the correlations found longitudinally show that there is a link between skill at categorising sounds before starting school, and later reading and spelling development. However, the failure to find a significant difference between groups I and III means that we cannot be sure that the link is a causal one. The only condition which produced a significant result involved learning about the relation between similar sounds and their alphabetic representation using plastic letters, which particularly helped progress in spelling. This difference could have been caused by sound categorisation, by learning about alphabetic letters, or by both these factors in combination. Without a control group taught only about alphabetic letters, we cannot distinguish between these alternatives. Hence this study offers only limited support for the hypothesis that rhyming and alliteration skills are important determinants of later progress in reading and spelling.

4.4.v. Conclusions

It is clear from the evidence reviewed in this section that rhyming skills are well-established in young children before they begin learning to read. Furthermore, longitudinal studies suggest that there is a causal relationship between early skill in rhyming and later reading and spelling development, although the exact nature

of this relationship remains to be firmly established.

4.4.vi. Rhyming skills and later reading development: A role for analogy?

We can now ask why rhyming might play a causal role in reading development. Rhyming involves not only phonological skills, but also an important cognitive skill - categorisation. A child who can group together a sequence of words which rhyme is forming a category of words which have a sound in common. Categorising words by sound may naturally help a child to learn about common spelling patterns, especially as categories of this sort often transcend simple letter-sound relationships (e.g. beak-weak-creak, light-fight-might). Children may then be able to use these categories to make predictions about spelling and sound relations in the way required for analogy.

If children expect words that sound the same to be spelled in the same way, then they should generalise from one word to another on the basis of spelling when learning to read, and from one word to another on the basis of sound when learning to spell. Once a child becomes aware that words which have sounds in common also share common orthographic sequences, then in principle that child can make inferences about the sound of an unfamiliar written word from its spelling pattern, and inferences about the spelling of an unfamiliar word from its sound. Hence rhyming may be important for learning to read and spell partly because it leads a child naturally into analogy. This possibility will be examined more closely in the experiments in this thesis.

4.5. Segmentation

We will now turn to evidence for children's ability to segment words into their constituent sounds. This is also an important skill for the use of analogy in reading and spelling, as to make an analogy from a known word to a new word both words have to be segmented into parts which share the same spelling patterns and parts which differ. There are lots of studies which look at segmentation skills, many involving quite complex tasks, for example, phoneme deletion, phoneme addition, phoneme manipulation and phoneme substitution. Segmentation studies will thus be considered in terms of task requirement. The relationship between segmentation skills and reading achievement will then be considered. Finally, evidence concerning the type of segmentation required for analogy will be considered.

4.5.i. Segmentation using concrete stimuli

One of the first people to look at children's ability to segment words into their constituent phonemes was Elkonin (1971, 1973; cited in Ehri, 1979), who suggested that phonological segmentation was the major hurdle in learning to read. He hypothesised that beginning readers could be helped to analyse the sequence of sounds in words if the spoken units within words could be represented concretely. Phonemes are abstract concepts, and so the use of concrete units may help a child to focus on and objectify the sounds which represent the sequence of phonemic units within words.

Elkonin proposed a series of instructional stages by which segmentation could be trained. In the first stage, the child was shown a picture of the word to be segmented, with a series of empty

boxes below it to indicate the number of sounds in the word. Next, the child was trained to "pronounce every sound in succession in a drawl" (p. 104). As each sound was stressed, a counter representing the sound was placed under the picture in the relevant box. The child then had to name the sounds corresponding to the counters. Eventually, the child was able to segment words orally without the help of counters.

Elkonin showed that 6 year old children who previously could not analyse words into sounds were able to segment 82% of new words correctly following instruction with his programme. A control group given training with the counters but no pictures could segment only 31% of the new words, and a second control group taught purely orally could not segment the new words at all. This result suggests that, if concrete materials are used, children can be taught to segment words phonologically before they begin to learn to read. However, phonological segmentation does not seem to come spontaneously to children before they learn to read.

The question of when phonological segmentation skills are acquired was studied more extensively by Calfee, Lindamood and Lindamood (1973). They used a similar method to that pioneered by Elkonin to examine segmentation skills in children from kindergarten (age 6) to twelfth grade (age 18). Their method was to give children the Lindamood Auditory Conceptualisation Test, which requires children to arrange coloured blocks to represent sounds. The test sounds are either discrete units, like s-s-n, or integrated units, like 'ips'. 660 children took part in the study.

Calfee et al. found that representation of the integrated units was significantly more difficult than representation of the discrete

units at all ages. Performance also varied with IQ. At age 6, high-ability children were able to segment approximately 75% of the discrete units and 17% of the integrated units, whereas low-ability children were segmenting approximately 40% of discrete units and 8% of integrated units. Interestingly, the high-ability children showed a jump in performance on the integrated units at age 7, when reading instruction began. Between ages 6 to 10, low-ability children were much worse than high-ability children on the discrete task as well as on the integrated task, after age 10 they were only poor at segmenting the integrated units in comparison to the high-ability children. Finally, performance on the Lindamood Auditory Conceptualisation Test was a good predictor of later reading achievement, accounting for over 50% of the variance on the Wide Range Achievement Test of reading and spelling. As Calfee et al. state, this suggests that segmentation is significantly related to reading and spelling performance. However, the relationship is purely correlational, and so it is not clear whether the ability to segment integrated units precedes reading development, or whether reading development causes segmentation skills to develop. The data presented by Calfee et al. show that children's ability to segment integrated units (phonemic segmentation) before they learn to read is minimal (17% correct performance).

4.5.ii. Segmentation using counting

A similar conclusion to that of Calfee et al. was reached by Liberman, Shankweiler, Fischer and Carter (1974). They used a tapping task to assess children's segmentation skills. 4, 5 and 6 year old children were shown how to segment words into syllables or phonemes, tapping once for each segment (e.g. 'popsicle' = 3 taps (syllable);

'toy' = 3 taps (phoneme)). The children were then tested on 42 new words. Performance was measured by whether children could reach a criterion of tapping correctly on six consecutive trials.

Liberman et al. found that the syllable segmentation task was easier than the phoneme segmentation task at all ages. On the syllable task, criterion was reached by 46% of the 4 year olds, 48% of the 5 year olds, and 90% of the 6 year olds; whereas on the phoneme task criterion was only reached by 0% of the 4 year olds, 17% of the 5 year olds, and 70% of the 6 year olds. Liberman et al. concluded that explicit knowledge of phonemes was less accessible than explicit knowledge of syllables.

However, the big difference which they found between syllables and phonemes could have arisen from the nature of their task. Tapping is a rhythmic task, and the rhythm in single words is in the syllables rather than in the phonemes. Thus if tapping had not been used, the phoneme segmentation of the younger children might have been better. Again, however, the results seem to suggest that phonemic segmentation skills are virtually absent before children begin learning to read. In contrast, syllable segmentation skills seem well-established.

Treiman and Baron (1981) suggested that the tapping task used by Liberman et al. may have underestimated children's segmentation skills for another reason - the need to tap once for each perceived unit. They argued that a control task measuring counting skill should also have been included. They repeated Liberman et al.'s study on 6 and 7 year old children, using nonsense words (e.g. 'vaz', 'datu'), and included a condition where discrete non-speech sounds were presented. Instead of tapping, the children had to put out one

counter for each phoneme. This avoided the problem of rhythm inherent in tapping. Phoneme counting was significantly more difficult than syllable counting, with counting discrete stimuli being easiest of all, for both ages. In the phonemic segmentation task the 6 year olds performed correctly in 42% of trials, compared to 58% correct performance for the 7 year olds. However, no interaction between age and task was found in a two-way analysis of variance performed on these factors. Treiman and Baron concluded from this that the increase in phoneme counting with age arose from an increased ability to count rather than an increase in phonemic awareness.

Until other studies are performed which include similar controls for counting skill, it is difficult to assess the role of counting skill in phonemic tasks. Furthermore, as Treiman and Baron found that phonemic segmentation correlated significantly with a measure of nonsense word reading, it could also be reading ability which was causing the increase in phonemic segmentation. It is impossible to tell from these results whether phonemic segmentation is a precursor of reading or a consequence of it. However, the main result, namely that phonemic segmentation is significantly harder than syllabic segmentation, supports the findings of Liberman et al.

The question of whether segmentation skills determine reading acquisition was also examined in a similar study by Tunmer and Nesdale (1985). They asked 63 6 year old children to tap out the sounds in words which either contained digraphs (e.g. 'oo', 'ee') or did not. The children's success with the former group of words was strongly related to their reading scores - a relationship which was significant even after verbal skills (as measured by a vocabulary test) were partialled out. However, nothing can be concluded about

the direction of cause and effect in this study. It is at least as possible that the children's experiences in reading determined their performance in the tapping task as the other way round. Indeed we shall see later that another result in this study did suggest a considerable influence of knowledge gained from reading on the phonological task.

4.5.iii. Segmentation using phoneme deletion and manipulation

The conclusion that phonemic segmentation is very difficult for young children has received further support from a number of studies which have measured segmentation skills by asking children to delete phonemes from words. However, one problem with such studies is that they measure phonemic segmentation skills indirectly. While children's failure on these tasks is normally interpreted as arising from an inability to analyse words into phonemes, it could equally be the case that the extraneous task requirements (e.g. subtraction) were causing the poor performance.

For example, Bruce (1964) asked children aged from 5 to 7 years to delete phonemes from 30 familiar words, such as 'pink', 'hill', and 'monkey'. The task was to say the word that would be left if one sound (first, middle or last) was deleted, for example, 'pink' -> 'pin', 'hill' -> 'ill', 'monkey' -> 'money'. Children were first given practice at deleting sounds, and then received the 30 test items. Bruce found that children with a mental age of less than 7 years were unable to perform the task. He concluded that a certain level of basic mental ability was necessary before children could analyse words in this way. However, this task is a very difficult one, requiring subtraction skills as well as segmentation skills. It could be that children's problems arose from an inability to perform

subtraction of phonemes, rather than from an inability to segment/analyse words into phonemes. To control for this possibility, Bruce should have included a control task requiring subtraction alone. It cannot be concluded from this study that a mental age of 7 is a pre-requisite to phoneme deletion.

Fox and Routh (1975) also used a deletion task to examine segmentation skills. They asked 50 children aged from 3-7 years to segment sentences into words, words into syllables, and syllables into phonemes. Simple sentences such as "Peter jumps" were used, and segmentation was induced by asking children to say "just a little bit" of what the experimenter said. In the case of "Peter jumps", the required responses were "Peter", "Pete", and "Pe". Successful segmentation was rewarded by a raisin.

Fox and Routh found that the children were at ceiling on the sentence and word tasks from 4 years of age onwards. Performance on the syllable segmentation task was not so good, with 3 year olds performing at around 25% correct, 4 year olds at around 60% correct, and 5-7 year olds at around 85-95% correct. Thus children could successfully segment sentences into words and words into syllables from age 4 onwards. Phonemic segmentation was more difficult, but even 3 and 4 year olds were successfully segmenting syllables into phonemes some of the time. This shows that some phonemic segmentation ability is present prior to learning to read.

4.5.iv. Segmentation using phoneme manipulation

If children can rearrange the phonemes in words, this would be convincing evidence that they are aware of the individual phonemes in words. Alegria, Pignot and Morais (1982) devised such a task.

Children aged 6-7 years were given three lists of words. For one, they had to reverse the order of two words, for another, the order of two syllables, and for the third, the order of two phonemes. Half the children were at a school where reading was taught by a phonic method, and the other half were at a school using a whole word method of teaching reading. Alegria et al. found a wide spread of scores, and a big difference between children from the two schools. Children taught by the whole word method performed extremely poorly in the phoneme reversal task, and were significantly worse at the task than the group taught by phonics (15.4% correct and 58.3% correct respectively). No such difference was found in the syllable reversal task.

The authors concluded that the difference between the two groups supported the notion of a 'reciprocal relation between reading instruction and awareness of phones' (p. 454). The nature of this reciprocity is not yet clear. However, this study again shows that syllable manipulation is unaffected by reading. While it seems that phonemic awareness is partially dependent on learning to read, and furthermore on how reading is taught, the same does not seem to be true of syllables. We will now briefly examine why this should be the case.

4.5.v. The relationship between reading and phonemic segmentation: studies with children

One interpretation of the finding that syllabic segmentation is initially better than phonemic segmentation, with phonemic segmentation catching up at around age 7, is that phonemic segmentation is in some way dependent on learning to read. For example, learning to read may provide children with an insight into

how words are built up from phonemes. An alternative possibility is that once they can read, children use a spelling strategy to perform phonemic awareness tasks, equating the number of phonemes in a word with the number of letters in the written form of the word. This alternative possibility is supported by experiments by Ehri and Wilce (1980), and by Tunmer and Nesdale (1985).

Ehri and Wilce argued that a linguistic analysis would predict that children should hear the same number of phonemes in a word like 'pitch' as in a word like 'rich'. However, if children used a spelling strategy to segment such words, then they should attribute an extra phoneme to 'pitch' as compared to 'rich'. Ehri and Wilce tested this experimentally by asking 9-10 year old children to segment words such as 'pitch', 'rich', 'new', and 'do' into phonemes. The segmentation task followed Elkonin (1973), the children being asked to represent each phonetic segment in a word by a counter. Training was given on the task prior to the experiment, but no pictures were used. The children were then asked to spell the test words.

Ehri and Wilce found that children heard an extra phoneme in 13.7/24 of the words with extra letters, compared to 0.6/24 of the words without extra letters. This suggested that the children were using a spelling strategy to perform the phonemic segmentation task. Ehri and Wilce then went on to show that children taught nonsense words such as 'banyu' and 'tadge' put out more counters in a phoneme segmentation task than children taught the equivalent nonsense words 'banu' and 'taj'. Again, this implied that the children were relying on the spelling of words to perform the phonemic segmentation task.

While this is a convincing experimental demonstration of the

influence of orthographic knowledge on phonemic segmentation, it is a pity that Ehri and Wilce did not make any developmental comparisons, by including a group of younger subjects. One possibility would be that children who cannot read words like 'pitch' and 'rich' think that they have an equivalent number of phonemes. An alternative possibility would be that, without being able to spell the words, children cannot begin to try and segment them phonemically. A study involving children of different age groups is required to sort out this question.

A study which does examine the influence of orthographic factors on the phonemic segmentation skills of younger children is that of Tunmer and Nesdale (1985) (see also 4.5.ii.). Again, however, only one age group was studied, this time a group of 6 year olds. The children were asked to segment both words and pronounceable nonsense words phonemically, using Liberman et al.'s tapping task. Some of the words and nonsense words contained single-phoneme vowel sounds which are normally represented by digraphs in real words (e.g. '-ee', '-oo'). Tunmer and Nesdale predicted that, if children were using spelling knowledge to help them in the phonemic segmentation task, then they would make 'overshoot errors' (i.e. extra taps) on the vowel digraph words.

This prediction was confirmed. Tunmer and Nesdale found that significantly more overshoot errors were made on the digraph words and nonsense words than on the non-digraph words and nonsense words (60% and 56% compared to 21.5% and 34.8%, respectively). They also found that children who performed poorly on a separate test of nonsense word decoding were much better at segmenting non-digraph real words than non-digraph nonsense words, whereas good decoders

could segment both types of word. They suggested that this was because the poor decoders used a 'grapheme' or spelling strategy to perform the phonemic segmentation task, and so were much worse at segmenting the nonsense words.

Again, this finding is consistent with the hypothesis that phonemic segmentation skills only arise after reading has begun, and are partly dependent on spelling knowledge, especially in the early stages of learning to read. Spelling knowledge seems to be important in developing the concept of a phoneme, which is essentially abstract.

4.5.vi. The relationship between reading and phonemic segmentation: studies with adults

The question of whether performance in this kind of task reflects a cause or an effect of learning to read can also be studied by looking at adult illiterates. Morais, Cary, Alegria and Bertelson (1979) compared a group of Portuguese illiterates to a similar group of adults who had been through an adult literacy programme. They gave both groups two tasks. One was to add a sound to a word ('alhaco'-'palhaco'), and the other to subtract a sound from a word ('purso'-'urso'). The added and deleted sound was the same throughout the session, but differed between subjects. The main result was that the illiterate group was very much worse at this task than the literate group, although they were able to manage some of the words (46% success in the addition task with real words). The illiterates were very poor at both tasks when nonsense words were involved. The authors concluded that the ability to analyse sounds was markedly affected by the experience of learning to read.

There are two reasons for being cautious about this conclusion. The first is that we cannot be sure that the two groups were equivalent in every way apart from reading. It seems unlikely that chance alone determined whether or not the subjects took adult literacy courses, and so there could have been some self-selection which could have been influenced by the people's different abilities. The second problem is that the biggest difference between the two groups was in the nonsense word condition. This raises the possibility that the problem for the illiterates was not so much with adding and deleting phonemes, but with nonsense words per se. Control conditions which involve nonsense words but no phonological analysis are needed. According to the Morais et al. hypothesis the illiterates would have no particular difficulty in such tasks.

The thesis advanced by Morais et al. has recently received some strong support in a paper by Read, Zhang, Nie and Ding (1986, in press). They took advantage of the fact that some Chinese have been taught an alphabetic version of written Chinese (pinyin) as well as the traditional Chinese orthography. The authors compared a group of people taught pinyin with another group who had learned only the traditional orthography on tasks which were the exact equivalents of the Morais et al. test. The results of the study were strikingly similar to those produced by Morais et al. The pinyin group were better in both tasks, and once again the difference was more pronounced with nonsense words than with real words. The non-pinyin group reached roughly the same level with real words as the Portuguese illiterate group. Thus the skill in question was not wholly dependent on reading. The authors conclusion was that 'while the ability to recognise sameness and difference between phonemes within words appears to be a precondition for alphabetic literacy....the ability

to manipulate (add and delete) phonemes within words appears to be a consequence of it'.

Again some caution is needed about this conclusion. Once more there is a pronounced difficulty with nonsense words, and no control to ensure that this difficulty is a genuinely phonological one. There is also a possibility that the two groups in this study were not really comparable. Pinyin was introduced in Chinese schools in the late forties, and thus the non-pinyin subjects were on the whole older people who had been to school before this time. The discrepancy in the two groups' ages was quite considerable, and so age could have been a factor in the differences found. Thus we cannot be sure from these two studies whether phonemic segmentation is purely a consequence of reading.

4.5.vii. Conclusions

A number of conclusions can be drawn from the studies reviewed so far. Firstly, there is strong evidence that children are able to segment words into syllables long before they learn to read. Secondly, the ability to segment words into phonemes only really develops once reading instruction commences. It seems that learning to read is very important for developing the abstract concept of a phoneme. Thirdly, children's segmentation skills seem to be heavily task-dependent. Even within a given task, different studies find varied performance (e.g. Bruce, 1964, versus Fox and Routh, 1975). We will now consider the significance of these findings for analogy.

4.6. The relationship between segmentation skills and analogy

How can the finding that syllabic segmentation skills precede phonemic segmentation skills be interpreted with respect to the kind

of segmentation required for analogy? As mentioned previously, phonemic segmentation per se is not necessary for making analogies between words. To make an analogy between 'beak' and 'peak', a child must only segment the word into onset and rime. Let us now turn to some experiments which look at exactly this kind of segmentation.

4.6.i. Initial phoneme deletion

One experiment which required children to segment words into onset and rime was carried out by Calfee (1972). He asked 132 kindergarten and 138 first grade children (mean ages approximately 5 and 6 years) to play a game resembling Pig Latin, in which the children were asked to strip the initial phoneme from words. The children were told "When I say 'greet', you should say 'eat'; when I say 'ties', you should say 'eyes'", and so on. All the responses were real words, and Calfee used pictures of both the target and the response words to control for memory. A choice of three response pictures was provided for any given trial.

Following some practice trials to familiarise the children with the task ("If I say 'pies', you point and say 'eyes'"), several transfer trials were conducted. In Test 1, the children received new target words to segment, but the responses remained the same (e.g. 'spies-eyes'). In Test 2, new target and response words were used (e.g. 'mice-ice'), and in Test 3 target words were given in isolation without a choice of pictures of the response.

Calfee found that performance in the training phase was virtually perfect, with the children segmenting correctly in over 90% of trials. Transfer was also substantial, ranging from around 95% correct on Test 1 to around 84% correct on Test 3. There were no

differences for grade level. Thus very young children were able to perform well on this task. Although no details of reading ability are provided, it seems permissible to conclude from the kindergarteners' results that the ability to segment words into onset and rime is present even before children learn to read.

This interpretation of Calfee's results is supported by a study by Content, Morais, Alegria and Bertelson (1982), who studied pre-readers. They asked kindergarteners (mean age 5;7) to delete the initial phoneme from words, as in 'beak-eak', introducing the task as a game using puppets. The puppets spoke an invented language, one puppet making a mistake which the other puppet corrected. Three types of stimuli were used: words beginning with vowels, fricatives or plosives (no examples given). None of the children taking part in the study could read simple syllables.

Content et al. found that the children were very good at deleting initial vowels, performing correctly on 81% of the stimuli, but were less skilled at deleting initial fricatives (20% correct) or plosives (42% correct). However, following training on phonemic manipulation and blending, performance on the latter two tasks improved dramatically, by around 40% on each task. A control group of children who did not receive phonic training did not show such improvements. The effect of training was maintained at a follow-up six months later.

This study shows that even children who cannot read are able to segment words in the way that would be required for analogies to be made, and rapidly improve in this ability with practice. While initial performance levels were not high, (with the exception of the vowel detachment task), the children were able to respond correctly

on some of the stimuli, showing that segmentation skills were present in an elementary form. (While performance on the vowel task was good from the beginning, this task was more similar to syllabic segmentation than to phonemic segmentation.). The rapid improvement with practice suggested that initially low performance was due to difficulty in understanding the task.

However, some evidence for very poor performance on initial consonant deletion compared to other phonological tasks comes from a study by Stanovich, Cunningham and Cramer (1984). They gave kindergarteners (mean age 6;2) a number of phonological tasks, including initial phoneme deletion ('pink'-'ink'). The children in the study all had some pre-reading skills. Performance on this task was much lower than performance on any of the other tasks, which tested rhyme and alliteration skills and phoneme substitution. Half of the 49 children tested scored 0 on initial consonant deletion, and the average score of the remaining children was only 2.5/10. Thus if no training is provided, the kind of segmentation required for making analogies between the ends of words can be difficult for pre-readers. Clearly, task presentation is also important, as Calfee found very good performance even in his training trials.

One possible cause of the variation in performance on these tasks is that it is due to the way in which deletion is induced. A recent study by Content, Kolinsky, Morais and Bertelson (in press) supports this hypothesis. They gave 'preliterate' 4 and 5 year olds from public schools exactly the same initial consonant or vowel deletion task used by Content et al. (1982), again using puppets to present the stimuli. They found that children of both ages performed well in the vowel deletion task, which involved syllable deletion,

performance being at around 35% correct at 4 years and 65% correct at 5 years. Deletion of an initial consonant was much harder, especially at 4 years, where performance only reached 17% correct even after extensive feedback. 5 year olds were able to perform correctly on 52% of trials following similar feedback, although the performance of 5 year olds who received no feedback remained at around 12% correct. Thus 5 year old children who were not yet reading could manage initial phoneme deletion tasks when feedback was provided. On the other hand, feedback did not seem to help the 4 year old children at all.

The performance of the 4 year olds on this task contrasts with the high performance levels reported by Fox and Routh (1975), who used a different method of inducing deletion. Content et al. then repeated Fox and Routh's study on their group of 4 year olds. Performance shot up dramatically to around 75% correct. Thus these 4 year olds could segment syllables into phonemes following a small change in procedure.

We can conclude that pre-readers can segment words into onset and rime in the way required for analogies to be made once some training is given. We now turn to studies involving the deletion of final sounds, as in 'beak-bea', as this is the kind of segmentation required for making analogies such as 'beak-bean'.

4.6.ii. Final phoneme deletion

Very few studies involving the deletion of final phonemes have been carried out. However, the task used by Fox and Routh (1975) included final phoneme deletion, and they found that even 3 and 4 year old children could perform successfully on some trials. Thus it

seems likely that children would be able to segment words into beginning letters and final phoneme even before they were able to read, given some training on this task.

A study by Rosner and Simon (1971) provides limited support for this hypothesis. They gave children aged from kindergarten (5 years) to 6th grade (11 years) different phonemic analysis tasks, including tasks in which the children were required to omit the final consonant of a one-syllable word (e.g. 'belt' -> 'bel'), or to omit the initial consonant of a one-syllable word (e.g. 'lend' -> 'end'). They found that kindergarteners responded correctly on these tasks on 20% and 7% of occasions, respectively, compared to 81.8% and 70.2% correct performance by first graders (6 year olds).

The kindergarteners obviously had a limited ability to delete final phonemes, although performance on the initial phoneme deletion task was very low (7%) given the high performance levels found by Calfee and by Morais et al. However, it should be recalled that training was provided in these other studies. If Rosner et al. had given their children some kind of training, the performance of the kindergarteners might have improved rapidly. Even without training, Rosner and Simon do find some evidence for both kinds of segmentation ability before reading commences, although the performance of the kindergarteners pales beside that of the first graders, who had already begun to learn to read.

A task involving final phoneme deletion was also included in the study by Content et al. mentioned in section 4.6.i. 4 and 5 year old children played the same puppet game used in the other experimental tasks, but half of the children had to delete initial consonants and half had to delete final consonants. The results showed that initial

consonants were significantly harder to delete than final consonants at both ages, correct performance on each task being 21% and 36% at age 4, and 14% and 38% at age 5, respectively. In contrast, the authors reported that classifying words as beginning with the same initial consonant was easier than classifying words as ending with the same final consonant at both ages, thus ruling out an explanation based on perceptual saliency.

4.6.iii. Conclusions regarding segmentation and analogy

A number of conclusions can be drawn from these studies. Firstly, it seems that even pre-readers are able to segment syllables into phonemes if the task is presented in a certain way. Secondly, the kind of segmentation required for analogy is present in children before they learn to read. Final consonant deletion (required for analogies like 'beak-bean') seems to be easier than initial consonant deletion (required for analogies like 'beak-peak'), but both skills are present to a limited extent in 4 and 5 year olds. It seems likely that higher performance levels could be achieved by changing the task used - for example, Calfee gets much better results than the other studies, and Content et al. (in press) get higher performance levels than Rosner and Simon. Having shown that it is possible that segmentation skills of the kind required for analogy are present in young children before they start to read, let us now examine some of the literature on children's blending skills.

4.7. Blending

Blending skills are also necessary for a child to generalise from one word to another in the way required for an analogy to be made. There are very few studies on young children's ability to blend

sounds into words. However, the studies which have been done suggest that, young children are able to blend sounds early in the process of learning to read, and that training in sound blending can improve reading development.

4.7.i. Blending sounds into words

A study by Roberts (1976) examined 5 and 6 year old children's synthesis and analysis of simple words. The children were first tested for their ability to recognise single letters and give their related sounds. Children who were already reading fluently were excluded, leaving 40 subjects. Roberts then gave the children four different tasks:

1. sound synthesis: experimenter says /o/ - /n/; child must respond 'on'
2. sound analysis: experimenter says 'it'; child must respond /i/ - /t/
3. visual and sound synthesis: experimenter shows written word 'up'; child must respond /u/ - /p/: 'up'
4. visual and sound analysis: experimenter says 'at'; child must respond /a/ - /t/, and write 'at'.

All the children did all the tasks, but in different orders according to a Latin square design. The results showed that sound synthesis was significantly easier than all the other tasks, with children scoring an average of 9.4/10 correct. Thus even before they can read fluently, children are very good at blending sounds into words. Performance on blending from a written stimulus (task 3) was also good, with children scoring an average of 7.45/10. The difference between these two tasks was presumably due to the latter involving memory for which sound matched which written letter, in

addition to blending. So blending skills seem to be well-established in young children. Performance on the analysis tasks was less well-established. Children were good at the sound analysis, scoring 8.15/10, but not on the task of visual and sound analysis, where they scored on average 4.83/10. We turn now to studies which examine the relationship between sound blending and reading development.

4.7.ii. Training studies: reading outcome measures

The question of how blending skills are related to development in reading is less straightforward. A training study by Farmer, Nixon and White (1976) suggested that training in sound blending can subsequently facilitate learning to read. 20 5 year old children were involved in the study, and were chosen as being just on the verge of learning to read. The children were split into two groups, one group receiving training in blending, the other receiving training on picture-word pairs (a labelling task). The blending group received auditory training on vowel-consonant combinations made up of the six letters 'p', 'n', 's', 't', 'i' and 'o', (e.g. /ip/, /op/), and on consonant-vowel-consonant blends (e.g. 'pip', 'top', 'nis', 'nop'). The control group were given the same CVC blends as labels for pictures, and trained on these associations. Reading of eight new CVC words made up of the training letters was then tested for both groups.

Farmer et al. found that the sound blending group were significantly better than the control group at reading the transfer words, and at the sound blending subtest of the Illinois Test of Psycholinguistic^{tic} Abilities. The experiment was then repeated on 40 4 and 5 year old children. This time, the training group were superior to the control group in sound blending only, although the results for

reading were in the same direction as for the 5-6 year olds. Farmer et al. concluded that training in sound blending facilitated learning to read.

While this experiment provides some support for the hypothesis that skill in sound blending is important for reading, the results are not as clear-cut as Farmer et al. claim. Firstly, it is not clear whether the experimental group was actually learning much about blending, as 'training' simply consisted of hearing the VC and CVC blends, without any apparent explanation being given about how they could be built up through blending. The main benefit for the training group seems to have been that they heard sub-units of the CVC words as well as the complete CVC stimuli. Secondly, there was no pretest of reading skills. Thus it is possible that in the first experiment, the children assigned to the training group were actually ahead in reading anyway, and that this accounted for their superiority on the reading post-test and on the ITPA sound blending test. Finally, the labelling task seems to be of dubious relevance for the children receiving it, as the pictures were not labelled in a meaningful way (half of the labels were nonsense words). This could have led to the control group being less enthusiastic about the experiment, and so have depressed their performance at post-test. Hence it is premature for Farmer et al. to make claims about reading development from this study.

An experiment by Haddock (1976) suggested that blending training can improve the reading of nonsense words. She took 80 5 year olds, and divided them into three groups. The children were first pretested to ensure that they could not read the nonsense words (e.g. 'peef', 'teek') being used. They were then given blending training on some

new nonsense words for ten minutes daily by their class teachers. Training was either auditory, where practice in C-VVC or CVV-C blending was given orally, or auditory-visual, where similar training was complemented by the use of letter cards. The third group of children formed the control group, and spent ten minutes daily learning letter-sound correspondences. Training lasted for three weeks. Children were then retested on their reading of the nonsense words. Haddock found that the auditory-visual group read significantly more nonsense words correctly than the auditory group, who read significantly more words than the control group. She concluded that training in blending improved pre-readers' ability to decode nonsense words. However, training in blending was not as effective as training in both blending and letter-sound correspondences.

4.7.iii. Training studies: reading analogue outcome measures

Roberts' conclusion that blending skills may developmentally precede segmentation skills was not supported by a study by Fox and Routh (1976). Fox and Routh gave 20 4 year old children training in phonic blending, and compared their performance on a reading analogue task to that of 20 4 year olds who did not receive blending training. Half of the children in each group were proficient at segmenting syllables into individual speech sounds, and half were not. Blending training consisted of synthesising two sounds spoken by the experimenter into a word, following demonstration trials given by the experimenter. Feedback was provided. The reading analogue task given in the test phase required the children to associate letter-like forms (Greek letters) with spoken sounds, and then to read two lists of 'words' made up from pairs of these letter-like forms. The

combinations used resulted in meaningful words (e.g. 'me', 'see', 'say', 'way'). Performance on this task was compared for the trained and untrained groups, and also for the segmenters and non-segmenters within each group.

The results showed no effect of phonic blend training on later performance in the reading task. However, a significant effect was found for segmentation ability. The proficient segmenters in both groups learned the first test list significantly faster than the non-segmenters, and made significantly fewer errors. They were similarly significantly superior to the non-segmenters on the second test list. Furthermore, blending training seemed to facilitate the performance of the segmenters in reading the second test list, as they were significantly faster on this list than the segmenters who did not receive blending training, and also made significantly fewer errors.

Fox and Routh concluded from this that it was segmentation ability rather than blending skill which was important for decoding unknown written words. They also concluded that segmentation skill was a necessary pre-requisite for blending training to be effective, as children who were not proficient in segmentation did not benefit from training in blending. There are two points to be made here. Firstly, it is not clear whether the reading analogue test does measure skill in reading unknown written words. For example, segmentation may be more important for decoding pairs of Greek symbols than it is for reading real words. Secondly, it is important to note that no training in segmentation was given. Hence the relationship found between segmentation ability and performance on the reading analogue test was purely correlational, and may have

arisen from something other than segmentation skill per se.

One possibility is that segmentation proficiency reflected children's pre-reading skills, which were not tested. As all the children came from professional and executive backgrounds, some of them may already have had some reading instruction at home. This alternative hypothesis could be tested by training some children (matched for pre-reading skills) in segmentation, and then seeing whether phonic blending training only helped those trained in segmentation. Without this control, it is too early to conclude that segmentation ability is necessary for blending training to be effective. This design was used by Fox and Routh in a later study (see 4.8.i).

4.7.iv. Conclusions

The studies reviewed in this section have shown that blending skills are well-established in young children before they learn to read. The precise nature of the relationship between blending and segmentation remains to be established, however, and the relationship between blending skill and reading development is uncertain. Both these issues are considered in studies which have examined blending and segmentation skills together. These are reviewed in the next section.

4.8. Blending and segmentation

A number of studies which look at both segmentation and blending together have also been carried out. The possession of both these abilities in combination has been thought to be very important for success in learning to read. For example, Lewkowicz (1980) stated that the main determinant of reading development was phonemic

awareness, by which she meant segmentation and blending skills "Blending and segmentation, then, can be regarded as the basic phonemic awareness tasks". (p. 691). Experiments which consider these two skills together will now be discussed.

4.8.i. Training studies: real words

A training study involving both segmentation and blending was carried out by Fox and Routh (1984). They took 31 kindergarteners (mean age 6 years) who could not segment syllables into phonemes. 10 were then trained in segmentation, 10 were trained in both segmentation and blending, and the remaining 11 formed an untrained control group. In addition, 10 children already proficient in segmentation formed a second control group. Segmentation training involved learning the beginning and end sounds in CVC words like 'man' and 'pig' (e.g. 'man': 'm-an', 'pig': 'p-ig'). Blending training involved combining two sounds into a word, as before (e.g. 'm' - 'an': 'man', 'p' - 'ig': 'pig').

Following training, a reading analogue test identical to that used in the 1976 study was given. Performance of the different control groups on this test was then compared. The results showed that only the group receiving segmentation and blending training and the proficiently-segmenting control group were able to learn the reading task. The untrained control group and the segmentation training group were completely unable to perform the task. However, the group trained on segmentation and blending still performed significantly more poorly on the reading task than the proficient segmenter control group.

Fox and Routh had expected that the children trained only in

segmentation should do as well as those trained in both segmentation and blending. However, they found that segmentation training without blending training did not facilitate performance on the reading task at all. As the authors themselves state, an experimental group trained in blending alone is required to sort out the independent contributions of segmentation and blending skills. It seems likely that the control group already proficient in segmentation were equally skilled in blending, both here and in the 1976 study. Furthermore, as shown in section 4.7.iii., it is not clear exactly what skills are required for successful performance in the 'reading analogue' task, which may simply measure segmentation ability. The best conclusion that can be drawn from Fox and Routh's work is that both segmentation and blending skills are important for reading development.

The opposite hypothesis to the idea that blending precedes segmentation has been put forward by Skjelfjord (1985), who argued that segmentation skills were a necessary prerequisite for the acquisition of blending. Skjelfjord stated that "Logically, skill in analysis is a precondition for skill in synthesis: to construct a whole one has to be aware that this whole consists of parts.." (p.55).

In support of his hypothesis, Skjelfjord reported a training study carried out by Carlsten (1984) in Norway. Carlsten trained first graders (around 7 years old) in oral segmentation for a period of 20 weeks, using Skjelfjord's method of asking children to 'feel out' the words in their mouths (articulatory cues). Their performance in tasks which involved segmenting, blending and reading nonsense words was then compared with a control group who had received the

normal run of teaching during the same period. The experimental group surpassed the control group in all three measures. However, it is difficult to know how much of this was due to their segmenting experience and how much was due to the extra time spent on a one-to-one basis with a teacher. As Carlsten reported that the children all received classroom reading instruction for the duration of the experiment using "the usual sounding technique", the experimental group could have received instruction in blending while learning to read. It is also possible that the reading teaching in itself helped the development of blending and segmentation skills. It is impossible to disentangle the direction of cause and effect in this study, especially since an unseen control group was used.

A training study which looked at the relationship between reading development and both blending and segmentation skills was carried out by Goldstein (1976). His hypothesis was that there should be a reciprocal relationship between blending and segmentation and reading, with blending and segmentation helping reading development, and reading instruction similarly improving blending and segmentation.

23 4 year old children took part in the study. The children were first pretested on their blending and segmentation skills. For the blending test, the children were asked to guess the name of a 'secret picture' which the experimenter held hidden in his hand, while the experimenter said the name of the picture in segments (e.g. 'kan-ga-roo', 'tuh-ea'). The child had to blend these segments into whole words to discover the name of the hidden picture (kangaroo, tea). Wooden blocks were used to provide the child with a concrete representation of the number of sounds spoken by the

experimenter, and the child was required to imitate each sound prior to blending. For the segmentation test, the experimenter said the word to be segmented while placing the associated picture in front of the child to aid memory. The child was then required to segment the word in the way that the experimenter had just done during the blending test ('say it in a funny way'). Children were either asked to segment the words which they had just received for blending, or new words.

During this pretesting, Goldstein found that blending was easier than segmentation for the 4 year old subjects, which supported Roberts' findings, and that both tasks were easier with syllables than with phonemes. The children were then split into two groups. One group was given 13 weeks of reading instruction, which mainly consisted of learning letter-sound correspondences, and of training in building up words. The other group received reading-related activities, such as having stories read to them, and learning letter names. Blending and segmentation skills were then re-tested, and a separate test of reading achievement was also administered.

Blending and segmentation ability at pretest was significantly related to later reading skill as measured by the reading achievement test. However, reading instruction did not improve blending and segmentation performance compared to pretest any more than reading-related activities - while the experimental group did score more highly than the control group on these tasks, the difference was not significant. Goldstein concluded that the results partially confirmed his hypothesis of a reciprocal relationship between learning to read and word analysis and synthesis skills.

Goldstein's study clearly suggests that blending is easier than

segmentation. The children in Goldstein's study were only 4 years old, and yet could successfully blend together 60% of the syllables and 36% of the phonemes which they were given at pretest. This was significantly superior to their performance in segmentation, although performance here was also good. The children were able to segment 56% of the new words into syllables and 26% of the new words into phonemes.

Given these differences, it is a pity that Goldstein did not analyse the post-test results for blending and segmentation separately. It is possible that reading instruction may help the development of the two skills to different extents. As segmentation seems to be harder than blending, learning phonic reading skills could well help the development of segmentation relatively more than the development of blending skills. This could then explain why Goldstein only achieved partial support for the second part of his hypothesis, which was that reading should help the development of both segmentation and blending.

4.8.ii. Training studies: nonsense words

A recent study by Treiman and Baron (1983) compared the effects of segmentation and blending training on reading. They gave children both blending and segmentation training, and then tested their reading of related and unrelated words (experiment 2). 20 5-6 year old children took part in the study. Pre-testing ensured that the children could not already read any of the words being used, and could not already segment words into phonemes. The children were then taught to segment and blend syllables like 'hem' and 'lig' auditorily, the task being presented as a game involving puppets.

The segmentation training consisted of the puppet segmenting syllables spoken by the experimenter. For example, if the experimenter said "hem", the puppet said "h - em". The children then learned to work the puppet for themselves, and training continued until they could segment all 4 syllables given in one session correctly. The blending training consisted of the puppet saying a syllable in segmented form (e.g. "h - em"), and the child then blending the segments to make a syllable ("hem"). The same syllables were given for both segmentation and blending. In the control condition, the children simply repeated spoken items after the experimenter, using the puppets (e.g. "diz", "vok", "iz", "ok"). Children received both the experimental and control conditions in each session in a counter-balanced order, four sessions being given over four days.

Post-testing was given on the fifth day, and involved reading the training items. The children were shown how the segments of some of the syllables were represented alphabetically (e.g. 'h', 'em'), and were trained to read these segments. They were then given the related full item to read ('hem'), and this was compared to performance on reading an unrelated item (e.g. 'lig'). Both items had thus been encountered during the auditory training, but only segments of the related item had been met visually. Treiman and Baron found that performance on the related items was significantly better than performance on the unrelated items if auditory training on the items had previously been given. In the control condition, there was no difference in performance on the related and unrelated items.

Treiman and Baron concluded that phonemic analysis training facilitated later reading performance. However, it is not clear from

their study whether the blending training or the segmentation training had a stronger effect on later reading. This question could be sorted out by comparing the performance of children taught only to segment in the training phase with that of children taught only to blend. However, it is clear that training in both blending and segmentation did facilitate the later reading of related items, even though the effects in this experiment seem to be very stimulus-specific. The question of which skill comes first is not answered in this study.

4.8.iii. Longitudinal studies

Skjelfjord's idea that segmentation precedes blending was not supported by a longitudinal study carried out by Perfetti, Beck and Hughes (1981). They examined the relationship between blending and segmentation skills and reading when different methods of teaching reading were employed. 82 6 year olds and 17 7 year olds took part in the study. The children were either following a reading programme based on the whole-word method of teaching or a programme based on phonics.

Prior to the commencement of reading instruction, the children's blending and segmentation skills were assessed. The blending test required the children to synthesise isolated sounds produced by the experimenter into a word (e.g. /k/ - /ae/ - /t/: 'cat'). The segmentation tests used were Liberman et al.'s tapping task (see section 4.5.ii.), and a task requiring the child to delete a phoneme from a given word (e.g. "Cat without the /t/ leaves ?"). These tasks were administered in September, and then again at intervals during the study, namely in November, January and April. A test of reading achievement was also given at these times.

Using time-lagged correlations, Perfetti et al. found that blending skill was an important predictor of later reading achievement, regardless of the instructional method followed by the child. For segmentation, however, the relationship varied with instructional method. The early segmentation skill of children taught by whole-word methods did not predict reading ability at any of the later testing sessions, but early reading did predict later segmentation skill for the phonic group, which in turn predicted later reading ability. Perfetti et al. concluded that blending skills were necessary for reading: "success at reading depends on it" (p.45). Segmentation skills, however, were mediated by reading experience "It is reading itself...that enables the children to be able to analyse words and to manipulate their speech segments". (p.46).

4.8.iv. Conclusions about blending and segmentation

Blending skills seem to be well-established before children begin learning to read. Blending also seems to be easier than segmentation, as children are able to blend phonemes into words before they can segment words into phonemes. Finally, both blending and segmentation skills seem to be important for later reading development. However, learning to read similarly enhances blending and segmentation skills, especially in the case of phonemic segmentation, which is greatly improved by learning to read. Thus children have the blending and segmentation skills required for analogy available before they begin learning to read, but it seems possible that making analogies in reading could in turn enhance the development of these component skills.

4.9. Overall conclusions

A number of overall conclusions concerning the precursors of analogy can be drawn from all the studies reviewed in this chapter. First of all, categorisation skills seem to be well-established in children before they learn to read. This conclusion holds for both visual and phonological categorisation. Furthermore, there is evidence that children have strong expectations about the relationship between sound and print, expecting words which are spelled in the same way to sound the same and vice versa.

Secondly, there is evidence that children can chunk words into onset and rime before they learn to read. They are best at such chunking when presentation is auditory. However, if they are required to blend chunks together, then they are better at blending chunks which cut across the onset-rime division (CV-C). There is conflicting evidence about how children behave when the task is visual, but there is tentative evidence that they find CV-C chunking easier here.

Thirdly, there is strong evidence that children are skilled at rhyming before they arrive in school. Rhyming is also a kind of categorisation, and there is growing evidence that rhyming skills play a causal role in reading development. It is possible that this relationship is partly due to the kinds of categorisations which must be made about the spelling patterns in words if reading is to develop from single-word learning.

Finally, there is evidence that blending and segmentation skills are also present before reading commences, at least in the form required for analogies to be made. Children perform well in segmentation and blending tasks involving syllables, and seem to be

able to segment syllables into onset and rime, and similarly to blend onsets and rimes into syllables, which is sufficient for analogy. Phonemic segmentation is probably not present before some reading instruction is given, however.

CHAPTER FIVE

ANALOGICAL THEORIES OF SKILLED READING

5.1. Introduction

In recent years, the idea that adult or skilled reading may depend on analogy has grown in popularity, although analogical theories of skilled reading performance are still controversial.

The proposal that analogy may be the only process required to derive sound from print was first made by Glushko (1979), as a challenge to the widely accepted dual-route model of reading. The dual-route model postulates that there are two ways of deriving sound from print, one being via a lexical process (whole visual stimulus to lexicon to sound), and the other via a non-lexical process (grapheme-phoneme rules). In contrast, analogy theory proposes that all reading is lexically based, with new words being read by analogy to words which already have lexical entries.

As the literature in the field of reading development reflects a similar debate between visual (look-say) and phonological (spelling-sound rules) learning processes, the controversy about analogy currently taking place in the adult field is obviously relevant to developmental theory. If analogy can be shown to underly skilled reading, then it must develop at some earlier stage, and may also be an important strategy in early reading. The evidence for the use of analogy in skilled reading will thus be reviewed as briefly as possible. Its implications for reading development will then be discussed.

5.2.i. Criticisms of the dual-route model of skilled reading

In his original paper, Glushko (1979) criticised the current orthodoxy that reading new words aloud depends on the application of spelling-sound rules. As new words lack lexical entries, the dual-route model assumes that the only way to assign phonology to novel letter strings is through the operation of orthographic rules. The same rules are used to read nonsense words, which also lack lexical entries. These 'rules' are generally characterised as explicit knowledge of mappings from letters or letter units to phonemes ('b' -> /b/, 'ea' -> /i/), or as more general principles ('a terminal 'e' marks a long vowel').

Rule-based processes have also been used to explain why nonsense words are read aloud more slowly than real words (Frederiksen and Kroll, 1976), and why 'regular' words are read aloud more quickly than 'exception' words (Gough and Cosky, 1977). The explanations are, respectively, that the rule-based process is slower than 'reading out' a lexical entry, and that, assuming rule-based and lexical processes are activated simultaneously, candidate pronunciations produced by the two processes will conflict in the case of the exception words, and thus slow pronunciation. It can be pointed out here that even these tenets of dual-route theory seem contradictory. If the lexical process is faster than the rule-based process, then it is not clear why conflict should arise in the case of exception words, since the (correct) exception pronunciation produced by the lexical process should be ready to be output first, and so any conflict with the rule-based pronunciation will arise too late to matter. However, this contradiction in assumptions has been largely ignored by dual-route theorists (but see Coltheart, 1978).

The assumption that rule-based processes operate independently of lexical processes has led to the assumption that these processes actually represent different and separate routes to reading, which are also functionally independent psychological pathways. This position seems to be supported by evidence for a double dissociation in the acquired dyslexias. In brief, phonological or deep dyslexics, who cannot read nonsense words, are assumed to only possess the lexical route, while surface dyslexics, who regularise all exception words, are assumed to rely largely on the rule-based route (Marshall and Newcombe, 1973). Further evidence for two functionally separate routes comes from work which seems to show that there are two types of readers in the general population, "Chinese", who rely on the lexical route, and "Phoenecian", who rely on the rule-based route (Baron and Strawson, 1976). Baron (1979) has argued that children can also be characterised as either Chinese or Phoenecian readers.

5.3. Glushko's experimental evidence against the dual-route theory

The idea that there are two distinct routes for deriving sound from print is obviously very well-established. However, Glushko was able to show experimentally that nonsense words were not always pronounced in the way that a dual-route model would predict, and that there were different types of regular words. Both these findings are very difficult for a dual-route model to accomodate.

5.3.i. Evidence about nonsense word pronunciation

Glushko gave subjects words to read which were either regular (dean), exception (deaf), or nonsense (hean, heaf). The nonsense words were matched to the regular and exception words, and were thus either designated as 'regular' nonsense words or as 'exception'

nonsense words. The words were presented randomly, interspersed with filler words and nonsense words. According to the dual-route model, all nonsense words will be read by rules, and so there should be no distinction between different 'types' of nonsense word in terms of pronunciation latency. However, Glushko found that the exception nonsense words took 29 milliseconds longer to pronounce than the regular nonsense words, just as the exception words took longer (20 msec.) to pronounce than the regular words. In addition, 21.7% of the exception nonsense words were given an 'exception' pronunciation (e.g. 'heaf' pronounced like 'deaf'), compared to 6.2% of the regular nonsense words. On a dual-route model, all nonsense words should be pronounced regularly, as the spelling-sound rules should assign a regular pronunciation in every case.

Glushko's explanation for his results was that skilled reading depended on a process of analogy rather than on a combination of rule-based and lexical processes. He suggested that new or nonsense words were read aloud through the integration of orthographic and phonological information already in the lexicon, which was stored in the form of knowledge about whole words. In this way a nonsense word like 'hean' could be read by analogy to a word like 'dean', while a nonsense word like 'heaf' could either be read by analogy to 'deaf' or to 'leaf'. Such an explanation would predict that exception nonsense words would sometimes be pronounced in ways which 'break the rules'. In a later paper, Glushko (1981) was not explicit about whether analogy worked through the analysis and synthesis of pronunciations from many different orthographic neighbours (p. 62), or through a comparison with a single neighbour sharing terminal vowel-consonant orthography (p. 73). However, the assumption that these lexical entries are segmentable appears to be inescapable, as

to derive 'heaf' from 'deaf' requires segmentation and blending skills (see Chapter 4.5 - 4.8.). In this way, Glushko's characterisation of the lexicon differs from that of dual-route models, which make no assumptions about the segmentation of lexical entries.

It has been stated that the finding that some nonsense words were pronounced in ways that broke 'the rules' was impossible for strong dual-route models of the reading process to explain. However, weaker dual-route theorists, who allow some interaction between the outputs of the two routes, could argue that the mixed presentation of matched real words and nonsense words in some way primed the pronunciations assigned to the nonsense words, and that this priming explains Glushko's effects. A further objection is that the mixed presentation may have biased subjects towards using lexical strategies.

To rule out these explanations of his results, Glushko (1979) repeated his experiment using the nonsense word stimuli alone, and showed that the differences found in the first experiment were robust. 'Exception' nonsense words like 'heaf' were still given exception pronunciations significantly more frequently than 'regular' nonsense words like 'hean' (12.3% vs 5.3%), and similarly still took significantly longer to pronounce. This result provided further support for a model of reading based on analogy. A dual-route model cannot explain why some nonsense words are more likely to receive exception pronunciations than others.

5.3.ii. Evidence about real words: regularity and consistency

If words are read aloud by analogy to other words in the

lexicon, the idea that there are 'regular' words which reflect 'the rules', (and 'exception' words which break them), must obviously be re-examined. Glushko argued that any such distinction will be arbitrary anyway: even linguistic characterisations of regularity are purely descriptive, and do not reflect any inherent properties of different words. For example, a word like 'gave' appears to be regular, because it follows the rules: the vowel is lengthened by the terminal 'e'. The word 'have' is then an exception, as the vowel is short. However, Glushko argued that 'gave' should be re-classified as 'regular and inconsistent', as it is not the case that all words ending in '-ave' are assigned a unique and regular pronunciation. By contrast, a word like 'haze' has no inconsistent orthographic neighbours, as all single-syllable words ending in '-aze' are pronounced in the same way. Glushko suggested that words like 'haze' should be classified as 'regular and consistent', and so distinguished from words like 'gave' ('regular and inconsistent').

A dual-route model would predict similar pronunciation latencies for both 'gave' and 'haze', as it does not recognise any difference between different regular words. In contrast, an analogy model would predict differences in pronunciation latency between 'regular and consistent', 'regular and inconsistent', and 'exception' words, as pronunciation depends on a given letter string activating orthographic and phonological knowledge about analogous neighbours. If inconsistent knowledge is activated, this will cause differences in pronunciation latency. A dual-route model would only predict differences between the exception words and both types of regular words, irrespective of consistency.

Glushko therefore carried out a third experiment, in which he

gave subjects words of these three different types to read aloud. He found that regular and consistent words ('haze') were read significantly faster than either regular and inconsistent words ('gave') or exception words ('have'). Regular and inconsistent words and exception words were read aloud at the same speed. This result clearly goes against the predictions of a dual-route model. Glushko interpreted this result as further support for the importance of analogical strategies in reading.

5.3.iii. Criticisms of Glushko's work: the effects of frequency on consistency

Glushko's finding of differences in pronunciation latency with the consistency of a word's orthographic neighbours has been criticised by Parkin (1984), who found no evidence for a consistency effect if word frequency was held constant. He found that regular words like 'pill' were pronounced as fast as 'mildly inconsistent' words like 'glove' and 'calm'. Parkin argued that an analogy model could not accommodate these results, as 84% of his mildly inconsistent words would be defined as regular and inconsistent by Glushko, and should therefore be read significantly more slowly than the matched regular words. However, even though Parkin's subjects failed to pronounce the mildly inconsistent words more slowly than the matched regular words, they made five times as many errors in pronouncing the mildly inconsistent words as in pronouncing the regular words. Hence Parkin's failure to replicate Glushko's results could have arisen from speed/accuracy trade-off differences between the subjects in the two experiments.

Another failure to replicate the consistency effect was reported by Andrews (1982). Using a naming task, she also failed to find a

consistency effect when words were presented alone, but did find one when words and nonsense words were presented together (which was Glushko's task). One possible explanation for these failures to find a consistency effect with real words is that word frequency has an effect. Seidenberg, Waters and Barnes (1984) demonstrated that the differences found by Glushko could only be replicated for low frequency words. When word frequency was high, regular and exception words were read equally fast. This means that the consistency effect interacts with frequency, which suggests that some of Glushko's consistency effects may have been directly due to the inclusion of a few infrequent exception words in his experiments. Seidenberg et al. argued that the frequency effect posed problems for analogy theory, as the processes of analysis and synthesis should not have been affected by frequency.

While the frequency effect would not be predicted by analogy theory, it is easily accommodated by it. It can be assumed that very common words are so well practised that pronunciation is automatic, and does not rely on analogy. Words which are matched in frequency could be read at the same speed, irrespective of whether they are regular and consistent or regular and inconsistent, and the process of analysis and synthesis could be overridden for high-frequency words by the activation of stored pronunciations. An overriding mechanism of this kind is included in the multiple-levels model of reading put forward by Shallice (e.g. Shallice and McCarthy, 1985), which allows morphemic information to operate most rapidly and strongly. Furthermore, Seidenberg et al.'s findings are also problematic for dual-route theory, which predicts that all exception words should be read aloud more slowly than regular words, irrespective of frequency. Frequency should not affect the conflict

between lexical and rule-based processes which is assumed to slow the pronunciation of exception words. So Seidenberg et al.'s data pose problems for both dual-route and analogy models.

Parkin argued that an explanation based on 'reading out' high frequency words was "an implicit two-route model" (p. 290). However, as both processes are lexical, this is not the case. Two lexical processes are implicit in Glushko's model anyway. Glushko assumes segmentable lexical entries, and it can be argued that this assumption in itself leads to two processes for reading aloud, one involving segmenting the lexical entries (analogy), the other involving simply reading out the correct lexical entry. The lexical entries must be available in complete form to allow the processes of analysis and synthesis to operate ("an entire neighbourhood of words...is activated in memory". p. 62). If the words themselves are activated during the reading process so that analysis and synthesis can take place, they should also be available for reading out. Although Glushko does not seem to consider this possibility in his theoretical discussion, where he referred to activation as a "content-free" retrieval process, it seems to be inescapable given his assumptions.

It is clear that Glushko's results strongly question the assumptions of lexical/non-lexical dual-route theory, and raise the possibility that reading is a purely lexical process, even though it may operate both with and without segmentation. We will now briefly review other evidence which is incompatible with the notion of a non-lexical, rule-based route for reading regular and nonsense words. Most of this evidence is based on experiments with nonsense words, and is largely concerned with demonstrating lexical effects in

nonsense word reading.

5.4. Further evidence against a rule-based route

The first demonstration of lexical effects in nonsense word reading came from Kay and Marcel (1981), who showed that the pronunciation of nonsense words could be influenced by exception ('irregular') real word primes. Since dual-route models assume that irregular words and nonsense words are read by independent routes, no interaction would be predicted between the two types of words. Kay and Marcel found that the pronunciation of a nonsense word like 'yead' was significantly more likely to be 'irregular' if it was preceded by an irregular word like 'head' than if it was preceded by a regular word like 'bead'. Nonsense word pronunciation was not affected by priming with an orthographically dissimilar word, like 'shed'.

These results suggest that priming is orthographic rather than phonological. The only way in which dual-route models can explain the priming of nonsense words by exception words is to assume that recent pronunciations produced by the lexical and non-lexical routes remain in some kind of post-lexical output buffer, where they can influence subsequent candidate pronunciations produced by either route (allowing 'head' to prime 'yead'). However, the assumption that recent pronunciations can influence each other in this output buffer would predict that priming with 'shed' should also have an effect on the pronunciation of 'yead', as coding in the output buffer is assumed to be phonological. An explanation based on analogy avoids such problems, as analogy would only predict a priming effect for orthographically similar words: analysis and synthesis of a pronunciation depends on the activation of orthographic neighbours. A

given prime could then operate by biasing the analogy chosen to read the nonsense word. Hence, Kay and Marcel's results are very difficult for dual-route models to handle.

An experiment by Maccabe (1983) posed further problems for a dual-route model. She examined the pronunciation of nonsense words such as 'palt', which contain terminal vowel consonant sequences which are only found in irregular words (e.g. '-alt' in salt, malt, halt). She found that almost 50% of such nonsense words were given an 'irregular' pronunciation, even though on a dual-route model all such words should be pronounced regularly in accordance with the rules. However, it could be argued that the results are also problematic for analogy theory, as an analogy model would expect all pronunciations to be analogous to 'salt'. Yet there is one word to which analogies could have been made where '-alt' is pronounced regularly: 'shalt'. Furthermore, a comprehensive analogy model would have to predict analogies between the beginnings of words as well as between the ends of words. Hence a nonsense word like 'palt' may also be influenced by analogies to words like 'pal' and 'pally'.

Unfortunately, there have been no experiments comparing the effect of analogies between the beginnings and the ends of words. For example, it might be predicted that for a nonsense word like 'palt', beginning analogies ('pal', 'pally') conflict with end analogies ('salt', 'malt'), whereas for a nonsense word like 'walt', beginning and end analogies agree ('walk', 'wall', 'salt', 'halt'). It might thus be predicted that 'palt' would be pronounced like 'shalt', while 'walt' would be pronounced like 'salt'. This experiment remains to be done. However, this type of analysis is supported by a 'mini-experiment' reported by Kay (1985).

Kay asked some people how they would pronounce the two nonsense words 'pook' and 'wook'. She found that 'pook' was pronounced /pʊk/ 93% of the time, while 'wook' was pronounced /wʊk/ only 38% of the time. An analogy explanation based purely on terminal vowel-consonant orthography would have to predict that '-ook' nonsense words should generally be pronounced like 'look', while a dual-route model would predict that all '-ook' nonsense words should be pronounced like 'spook'. However, while there are far more end analogies for the pronunciations /pʊk/ and /wʊk/, ('book', 'cook', 'took', 'look'), the beginning analogies differ ('pool', 'poodle', 'pooh'; 'wool', 'wood', 'woof'). An analogy model based on analogies between both the beginnings and the ends of words should be able to handle the /pʊk/-/wʊk/ effect.

Further evidence for lexical effects in nonsense word reading comes from Rosson (1983). She showed that the pronunciation of nonsense words like 'louch' could be varied by semantic priming. If the prime 'sofa' preceded presentation of 'louch', 89% of pronunciations rhymed with 'couch', whereas if the prime was 'feel', significantly fewer pronunciations rhymed with 'couch' (75%). (It is assumed that the other 25% of pronunciations for 'feel-louch' rhymed with 'touch', but this is not explicitly stated). A drawback of the experiment was that there were no control primes (e.g. bank-louch), so that no baseline measure for the pronunciation of 'louch' was available for comparison. However, the finding that nonsense word pronunciation could be influenced by semantic priming was clearly a lexical effect, and so cannot be explained at all by dual-route models.

This experiment is a particularly important one with regard to

modified versions of dual-route theory, which have been proposed to handle some of the effects found by Glushko and by Kay and Marcel.

5.5. Modified dual-route theories: large-unit rules

Recently, some dual-route theories have been put forward which attempt to maintain the distinction between lexical and non-lexical routes for reading by expanding the notion of the rule-based route (e.g. Baron, 1979; Kay and Marcel, 1981; Patterson and Morton, 1985). These modified versions suggest that the notion of spelling-sound rules should be expanded to include 'large-unit' rules. These large-unit rules store spelling-sound mappings for orthographic units like '-eak' and '-ave', rather than simply storing letter/letter unit-phoneme correspondences.

Large-unit rules can provide an alternative to analogies, as Baron (1979) pointed out, since a nonsense word like 'yave' could be read by applying small-unit rules for the pronunciation of 'y', and large-unit rules for the pronunciation of '-ave'. To get around the problem of which rule is stored for '-ave', Kay and Marcel suggested that all alternative phonological correspondences for an orthographic segment were represented in the form of weighted alternatives. Thus there may be two rules for the segment '-ave', one strongly weighted (/ev/ as in 'wave'), and one less strongly weighted (/av/ as in 'have'). In this way, biassing effects of the kind found by Kay and Marcel for nonsense words could be explained by these weightings being susceptible to priming.

The concept of multiple large-unit rules for terminal vowel-consonant orthography makes a distinction between analogy models and modified dual-route models more difficult, as even

Glushko's exception nonsense word effects can be explained by large-unit rules. A modified dual-route model would explain the fact that the exception nonsense word 'heaf' is sometimes pronounced like 'deaf' by assuming that sometimes the rule '-eaf' -> /Ef/ is applied instead of the rule '-eaf' -> /if/. For a regular nonsense word like 'hean' there is only one rule ('-ean' -> /in/), and so pronunciation is always consistent.

However, not even a modified version of dual-route theory can explain Rosson's demonstration that nonsense word pronunciation can be influenced by semantic priming. To maintain dual-route theory, a further modification is required. This is the assumption that the lexical and non-lexical routes interact. However, this interaction would have to be at an earlier stage than the previously mentioned 'output buffer' proposed by Patterson and Morton (1985). Such an assumption would mean that both routes were effectively lexical, as any interaction must be at a lexical stage to enable semantic priming of nonsense words. The distinction between dual-route models and single-route lexical analogy models would then become impossible to make, either theoretically or empirically. Maintenance of a dual-route theory would thus become impossible.

5.6. Conclusions

It can be concluded that a single-route, lexical model of reading that works by analogy can best explain the findings of lexical effects in adult nonsense word reading. Such a model removes the need for non-lexical, spelling-sound rules. It will be recalled that such rules were thought to have psychological reality because they (1) explained the finding that regular words were read faster than exception words, (2) provided a mechanism for reading new words,

and (3) seemed to explain the reading performance of patients with surface dyslexia. It is clear that an adequate explanation for effects (1) and (2) is provided by analogy theory. Furthermore, recent findings of lexical effects in the errors made by surface dyslexic readers (Marcel, 1980) suggest that spelling-sound rules are no longer required to explain the reading performance of these patients.

If all adult reading is lexically based, it can be argued that the development of reading should also be a largely lexical process. This would defuse the 'great debate' between phonic and look-say methods of teaching reading (Chall, 1967), as such methods would not be developing psychologically separate pathways, but merely strengthening different aspects of lexical processing. Similarly, reports of individual differences in reading style between 'whole-word' readers (Chinese) and analytic, rule-using readers (Phoenecian) would not be picking up children (or adults) who actually rely on different and independent routes for reading, but would reflect different lexical processing styles.

If it is accepted that the development of reading should be thought of as a largely lexical process, it can further be argued that children should be able to use analogies in reading and spelling from an early age. As shown in Chapter 2, Marsh et al. assumed that analogy was only found in the final stage of reading development, which was equated with adult reading by Ellis (1984). However, there seems to be no a priori or empirical reason to assume that this should be the case. Children may very well be able to make analogies in the first stages of learning to read.

It could even be argued that children may rely more on analogies

in the earliest stages of learning to read, as at this stage they are not aware of the ambiguities of English orthography. For example, while 'beak' is a good analogy to use when reading 'peak', it is not a good analogy for reading 'break'. Alternatively, there may be no real development in children's ability to use analogies at all. Instead, increasing reading experience could affect the store of words from which analogies are made, so that performance with ambiguous analogies is influenced by previous experience. Without empirical evidence, however, there is no way of deciding between these alternatives. Empirical evidence for the use of analogies by young children will be presented in Chapters 6-12.

CHAPTER SIXCHILDREN'S ABILITY TO MAKE ANALOGIES BETWEEN THE
SPELLING PATTERNS IN WORDS

To make an analogy in reading, a child must be able to infer the pronunciation of a new word by using a known word with a similar spelling pattern as a basis for making an analogy. For example, to use a word like 'beak' as a basis for reading a new word like 'peak' or 'bean' by analogy, a child must take advantage of the spelling pattern common to both the known word and the new word (here '-eak' or 'bea-') to infer the pronunciation of the new word. Thus an ability to recognise that two words have analogous¹ spelling patterns is fundamental to the use of analogies in reading.

If a child knows a word like 'beak', analogies to words like 'peak' and 'bean' are valid, but not to words like 'bask' and 'bark', which also have three letters in common with 'beak'. Knowledge of a word like 'beak' might help a child to read a word like 'bark' to some extent, as some of the grapheme-phoneme correspondences in the two words are the same (e.g. 'b' = /b/, 'k' = /k/), but 'beak' cannot be used as a basis for making analogies to 'bark', as the common letters are not in the same orthographic sequence as in 'beak'.

One way to examine whether children are aware of the constraints on the use of analogies in reading is to see whether they can make

¹ Throughout these experiments, the term 'analogous' will be used to refer to words which have common orthographic sequences at either the beginnings (e.g. "beak-bean", "coat-coast", "skin-skip"), or at the ends (e.g. "beak-peak", "coat-boat", "skin-win").

predictions about the spelling patterns of words which sound similar to a word whose spelling pattern they have just been given. If children are given an example of a spelling-sound relation ('beak'), and then asked to choose the correct spellings of new words which sound similar to this model ('peak', 'bean') from an array of possible spellings (such as 'peak', 'perk', 'burn', and 'bean'), they should be able to use analogies between the spelling patterns of the model and the target words to help them in making the correct choice. Thus if children can make analogies between the spelling patterns in words, they should be better at selecting the spelling patterns of new analogous words when they are given a model from which analogies can be made than when they are not given such a model.

The aim of the first experiment was to see whether children could choose words which were analogous in spelling to words which the experimenter read for them. In order to examine whether young children were able to make such analogies between the spelling patterns in words, it was decided to begin by looking at this ability in isolation, by asking them to match the spelling patterns in words without asking them to read the words aloud. The method used was simply to show a child a new word, such as 'beak', read it for her, and then ask her to choose the spelling pattern of an analogous word, such as 'bean' or 'peak', spoken by the experimenter, from an array of words laid out before her. This task tests children's understanding of the relationship between orthography and sound, since in order to choose the spelling pattern of the analogous word correctly, the child must reason that similarity of spelling predicts similarity of sound, and hence that a word which sounds similar to another word probably has a common spelling pattern. In order to see how early such an ability develops, children who could not yet read

were included in the study.

Experiment 1: Using Analogies to Choose Words from an Array

Method

Subjects

Thirty-seven children took part in the study, all from the infant classes of a local primary school in a largely working class area of Oxford. The children were given the Schonell Graded Word Reading Test (1971) prior to the experiment to assess reading levels. Half of the children (N = 18) did not yet score on the test, and will be referred to as non-readers. The mean age of this group was 6;11 yr., range 6;6 - 7;7 yr. The other half (N = 19) had a mean reading age of 6;4 yr., the range was 6;2 - 7;1 yr. The mean age of this group was also 6;11 yr., range 6;7 - 7;4 yr. The fact that so many children who were relatively old were not yet reading probably reflects the socio-economic status of this area of Oxford. However, the children had normal verbal skills as measured by the British Picture Vocabulary Scales (Dunn, Dunn and Whetton, 1982). The mean BPVS score of the group was 97.9, s.d. 14.8 (the average for the population is 100).

Procedure

The children were seen four times, once for a pretest, and then for three separate experimental (Analogy) sessions.

Pretest

The main aim of the Pretest was to exclude children who could already read the words being used in the experiment. In the Pretest,

all the children in the infant classes of the school (58 children) were given all the Analogous words being used in the experiment to read (presented in a randomised list mixed up with words suitable for six year old readers), along with a random selection of the Control (non-analogous) words. Only children who were unable to read any of the Analogous words were selected for the experiment. This resulted in 37 children being chosen. The children were not given all the Control words at Pretest, as this would have involved pretesting 144 words, which was felt to be too many. However, as the children chosen were unable to read any of the Control words which were included in the Pretest, it is unlikely that they knew many of the Control words on which they were not pretested. Full details of the Analogous and Control words used are given below.

Analogy Sessions

The three Analogy sessions were given on different days, and the children received a different experimental condition in each session. The Analogy sessions were conducted in exactly the same way for each condition. In each session, the child was told that she was going to play a word game about working out words. The child was given a single word printed on a card (e.g. 'beak'), which the experimenter read for her, and was told that this was a 'clue' word. The experimenter then placed eight words, also printed individually on cards, in a randomly-determined order below the clue word, and asked the child to choose a word which was analogous to the clue word (e.g. 'bean'). This was simply done by the experimenter asking "Which one of these words says 'bean'?". An example using different words was given before each session. The words were printed in black type 1/2" high in lower case on white cards measuring 4" x 6".

Conditions

The three different conditions were:

1. Beginning, in which the child was asked to pick words from the array in front of her which were analogous to the clue word at the beginnings (e.g. beak: bean, bead, beat). The experimenter said "This word says 'beak'. Which one of these words says ('bean')?". Thus in the Beginning condition the child was asked to make analogies between the beginnings of the clue and test words.
2. End, in which the child was asked to pick words from the array in front of her which were analogous to the clue word at the ends (e.g. beak: peak, weak, speak). The experimenter said "This word says 'beak'. Which one of these words says ('peak')?". Thus in the End condition the child was asked to make analogies between the ends of the clue and test words.
3. No Clue, in which the child was asked to pick out words like 'bean' and 'peak' without a clue word present to help her. The experimenter simply said "Which one of these words says ('peak')?". The No Clue condition provided a baseline against which performance in the other two experimental conditions could be tested, as in the No Clue condition the child was asked to select Analogous words in the absence of any clue word.

Words

Two types of test words were presented on each trial, Analogous and Control (non-analogous) words. The Analogous test words (two given) shared either the initial consonants and vowels or the vowels and terminal consonants (hereafter referred to as 'rimes') of the clue words, so that they were analogous at either the beginning (beak-bean) or at the end (beak-peak). The Control words (six given)

were of six types, to control for all the different letter positions on which non-analogical responses may have been based (i.e. same initial letter as clue word, same medial letters as clue word, same final letter as clue word, same initial and final letters as clue word, same initial and final letters as Beginning Analogous word, same initial and final letters as End Analogous word). The Control words were matched as closely as possible in frequency to the Analogous words using the Carroll, Davies and Richman (1971) norms. Examples of the six types of Control words are as follows:

1. same initial letter as clue word: beak-bold
2. same medial letters as clue word: beak-spear
3. same final letter as clue word: beak-dock
4. same initial and final letters as clue word: beak-bark
5. same initial and final letters as Beginning analogous word: bean-burn
6. same initial and final letters as End analogous word: peak-perk

The Analogous and Control words were all printed singly on white cards measuring 4" x 6" in black type 1/2" high, just like the clue words. The eight words presented on each trial were laid out in front of the child in an order determined by random number tables. Thus if a child was choosing test words on some basis other than analogy to the clue words, the child would select a Control word rather than an Analogous word. To control for the possibility that the child was simply selecting a word which had three letters in common with the clue word (and in the same sequence), both the Beginning and End Analogous test words were given on each trial. The full list of all the words used is given in Table 6.1 (overpage).

Table 6.1

Full list of words used in Experiment 1

Clue	Analogous		1.	2.	Control		5.	6.
	Beg.	End			3.	4.		
BEAK	bean	peak	bold	spear	dock	bark	burn	perk
	bead	weak	berry	heal	mink	bunk	bend	wink
	beat	speak	born	dead	thick	bank	best	spick
HARK	harp	lark	hub	wary	elk	honk	help	lick
	harm	bark	herd	cart	pink	hook	hem	bank
	hard	dark	hear	carry	book	hawk	held	dunk
RAIL	rain	tail	rock	hair	fall	real	ruin	tall
	raid	hail	reef	lain	coil	reel	rind	heel
	raise	sail	root	pairs	till	roll	ruse	sell
SEEN	seed	queen	silk	cheese	noon	spin	send	quin
	seem	green	size	feel	mean	soon	sum	grain
	seek	keen	sits	beef	yarn	span	sack	kin
COAT	coach	float	calm	goal	shout	cast	catch	flat
	coast	boat	care	board	heat	cart	crust	boot
	coal	throat	cows	load	chart	cost	curl	threat
SKIN	skip	chin	skate	drill	lean	span	scamp	churn
	skim	pin	skunk	hid	coin	swan	scum	pan
	skill	win	sky	tie	barn	sign	skull	won

In order to counter-balance the order of the word sets and conditions, the children were split into three groups matched for age and reading age. The words were grouped into three sets of two clue words and their associated test words, the sets being respectively the 'beak' and 'hark' words, the 'rail' and 'seen' words, and the 'coat' and 'skin' words. Each word set was given in a different condition on a separate day. This meant that six lots of eight words were given on each session, three for each of two different clue words. An example using different words was also given before each condition, to familiarise the child with the 'word game'. The order of receiving the words and conditions was varied in two 3 x 3 Latin squares. As there were 37 children taking part in the study, the design was not completely balanced.

Predictions

It was expected that if children can make analogies between the spelling patterns in words, they should be better at selecting the Analogous words in the Beginning and End conditions, where they are given a clue word from which analogies can be made, than in the No Clue condition, where no clue word is present to form the basis of an analogy.

Results

The results were analysed by counting the number of Analogous words selected correctly in each condition. The mean number of words selected correctly is given in Table 6.2 (overpage), separated for readers and non-readers. The table shows that both groups were better at choosing Analogous words in the Beginning and End conditions than in the No Clue condition. For the readers, there seems to be no difference between choosing words which were analogous at the beginning and choosing words which were analogous at the end. The non-readers, however, were much better at choosing words which were analogous at the beginning than words which were analogous at the end, as performance in the End condition was not much better than performance in the No Clue condition.

Table 6.2

Mean number of words chosen correctly out of 6

	<u>Beginning</u>	<u>End</u>	<u>No Clue</u>
Non-readers	3.33 (1.33)	2.56 (1.92)	2.28 (1.32)
Readers	4.16 (1.61)	4.21 (1.27)	3.42 (1.92)
Total	3.76 (1.52)	3.41 (1.80)	2.86 (1.73)

Note. Standard deviations in parentheses.

In order to test the significance of these results, a 3 x 2 x 3(Order group x Reading Level (Readers and Non-readers) x Condition (Beginning, End and No Clue)) Anova was performed, with repeated measures on Condition, taking the number of words read correctly as the dependent variable².

If the children were making analogies between the spelling patterns in words, a main effect of Condition would be predicted, as the number of Analogous words selected correctly should vary with Condition. If the non-readers were making analogies between the spelling patterns in words in the same way as the readers, a main effect of Reading Level would be predicted. However, if the non-readers made analogies differently from the readers, or if the

²
Prior to performing the analysis, the distribution of the raw scores was examined for kurtosis and skew. The distribution did not depart markedly from normal. As Analysis of Variance has anyway been shown to be a robust technique which can handle some departure from normality (Box, 1953; Winer, 1971), it was felt to be unnecessary to transform the raw data. With two exceptions, this was also the case in all the other experiments, and the same procedure was followed in these experiments. A clear departure from normality was only found for the non-readers in Experiments 2 and 3, and so here non-parametric techniques were used in analysing the data.

non-readers were not making any analogies, an interaction between Reading Level and Condition would be predicted, as the non-readers should perform in a different way from the readers in the Beginning and End conditions only. The full Anova table is given in Table 6.3.

Table 6.3

Anova on the number of words chosen correctly in Experiment 1

	Sum of Sq.	d.f.	Mean Sq.	F	P.
1. Order (O)	4.65	2	2.32	0.72	n.s.
Reading (RL)	37.03	1	37.03	11.45	0.005
O x RL	6.01	2	3.01	0.93	n.s.
Error	100.27	31	3.23		
2. Condition (C)	13.02	2	6.51	3.12	0.05
C x O	10.96	4	2.74	1.31	n.s.
C x RL	2.57	2	1.29	0.62	n.s.
C x O x RL	12.53	4	3.13	1.50	n.s.
Error	129.29	62	2.09		

The Anova showed a significant main effect of Reading Level ($F_{(1,31)} = 11.45, p < 0.005$), which was caused by the readers choosing more words correctly overall than the non-readers (3.93 vs. 2.72). There was also a significant main effect of Condition ($F_{(2,62)} = 3.12, p < 0.05$). The difference between conditions was examined by comparing the mean scores for the group as a whole. Post-hoc tests showed that the effect was due to performance in the Beginning condition being significantly better than performance in the No Clue condition ($p < 0.05$, Tukey's). Performance in the End condition was not significantly different from performance in the No Clue condition. This is evidence that the children made analogies between the beginnings of words.

Discussion

Experiment 1 shows that children can correctly make predictions about the spelling patterns at the beginnings of words which sound similar if they are provided with a model from which analogies can be made. Thus they are able to use analogies between the spelling patterns at the beginnings of words in order to select analogous words from an array. This ability does not seem to vary with reading skill, as both the non-readers and the readers made analogies between the beginnings of words. This suggests that the ability to use the spelling-sound relation of a known word to predict the spelling-sound relations of new words is available to some extent even to children who cannot yet read any words on a standardised test of reading (such as the Schonell).

This is an important result. It suggests that even children who are only on the verge of reading have a sophisticated understanding of the connections between orthography and sound. They are aware that spelling-sound relations are often consistent across words, and that words which sound similar are generally spelled in the same way, and words with similar spelling patterns generally share similar pronunciations. The demonstration that very young children have an insight into the relation between sound and print suggests that even beginning readers might be able to make analogies between the spelling patterns in words when reading aloud. This question was examined in Experiment 2.

To examine whether children are able to make analogies between the spelling patterns in words when they are required to read the analogous words aloud rather than to select them from an array of potential spellings, the first experiment was repeated in a modified

form. The children were asked to make analogies between the spelling patterns in the same clue words and Analogous words, but this time instead of choosing the spelling patterns of Analogous words spoken by the experimenter, the children were required to read the Analogous words aloud for themselves.

The experiment was again presented as a word game about working out words. However, this time the child was given the 'clue' word and told that she should use the clue word to help her to read some other words that the experimenter would give her to try and read aloud. No mention of how the clue word might help in reading the other words was made by the experimenter. In addition to the Analogous words, the children were also given some of the Control words used in Experiment 1 to try and read. These words could not be read by analogy to the clue words.

Experiment 2: Using Analogies to Read New Words Aloud

The aim of the second experiment was to see whether children can make analogies in reading aloud on the basis of a word which they have just learned to read. Showing that children can recognise when words are analogous (Experiment 1) does not necessarily mean that they will use this knowledge in reading aloud. Reading aloud requires the child to produce a sound for a given spelling pattern, and faced with this task children may rely on building up a pronunciation letter-by-letter by using grapheme-phoneme correspondences rather than analogies. Even though children are capable of making analogies in a task where the sound of a new word is produced for them, they may not use this ability in a task where they have to produce the sound of the new word for themselves.

In Experiment 2, a single 'clue' word was again provided as a basis for analogy, and analogies between the beginnings and ends of the same Analogous words used in Experiment 1 were compared. Non-scorers on a standardised test of reading development (the Schonell Graded Word Reading Test) were again included in the study, in order to examine whether analogy is an important strategy in the beginning stages of reading. These children had been at school for a period of between one and six months.

Method

Subjects

Children from the infant classes of a local primary school were pretested on all the words being used, and only children who did not know any of the test words were selected for the experiment. The children were also given the Schonell Graded Word Reading test as a measure of reading level, and the British Picture Vocabulary Test as a measure of verbal ability. There were 36 subjects in all, of whom 14 were non-scorers (non-readers) on the Schonell. The mean age of the readers (N = 22) was 6;3 yr., range 5;9 - 6;9 yr., and their mean reading age was 6;8 yr., range 6;2 - 7;1 yr. The mean age of the non-readers was 6;0 yr., range 5;6 - 6;8 yr. The BPVS scores for the two groups were: Readers - mean score 109.3, s.d. 14.2; Non-readers - mean score 109.4, s.d. 14.4.

Procedure

The children were seen once for a Pretest, and then three times in three separate Analogy sessions, a different condition being given in each session.

Pretest

In the Pretest, all the children in the infant classes of the school (70 children) were given all the Analogous and Control words being used in the experiment to try and read. The words were presented in a randomised list interspersed with other words suitable for six year old reading levels. The aim of the Pretest was to select only children who could not read any of the words being used. This resulted in 36 children being chosen.

Analogy Sessions

The three Analogy sessions were all conducted in exactly the same way, except that a different experimental condition was given in each session. In each session the children were told that they were going to play a word game about working out words. The child was given a single word on a card (e.g. 'beak') which the experimenter read for her, and was told that this was a 'clue word'. Nine test words on individual cards were then placed one by one below the clue word for the child to read. Each word was removed after the child had attempted to read it, so that only one test word was visible at any time. No hint of how the clue word should be used was given by the experimenter, who simply said "This is your clue word. This word says '(beak)'. What does this say?" when presenting the other (test) words. An example using different words was given before each session. The clue and test words were printed in black type 1/2" high on white cards measuring 4" x 6" as previously. The order of presentation of the nine test words in each trial was determined by random number tables. Full details of the test words used are given below.

Conditions

The three different conditions were exactly as in Experiment 1, namely I. Beginning, where analogies could be made from the clue word to the beginnings of the Analogous test words; II. End, where analogies could be made from the clue word to the ends of the Analogous test words; and III. No Clue, where no analogies could be made to the test words as no clue word was provided.

However, in contrast to Experiment 1, the Analogous words given to the child varied with condition. In the Beginning condition, the children were only asked to read Analogous words which shared the beginning letters of the clue words (e.g. 'beak: bean, bead, beat'), the other six words presented on a given trial being non-analogous words. In the End condition, the children were only asked to read Analogous words which shared the end letters of the clue words (e.g. 'beak: peak, weak, speak'), and the other six words were again non-analogous words. In the No Clue condition, the children were given both the Analogous Beginning and the Analogous End test words to try and read. Only three non-analogous words were presented in the No Clue condition. This was done to check that the children could not read the Analogous words when they were presented without a model (clue word) from which analogies could be made.

Words

There were three types of test words, three of each type being presented on each trial. These were:

1. Analogous words (e.g. 'bean', 'bead', 'beat', or 'peak', 'weak', 'speak'), words which shared the beginning or end letters of the clue words, and could be read by making analogies from the clue words.

2. Common Letter (CL) words (e.g. 'bask', 'lake', 'bank'). These words also had three letters in common with the clue words, but the letters were not in the same orthographic sequence, so that the Common Letter words could not be read by analogy to the clue words. These words were matched as closely as possible in frequency to the Analogous words (using the Carroll, Davies and Richman (1971) norms). If the clue words help in reading these Common Letter words, improvement must be due to the clue words sharing some common grapheme-phoneme correspondences with the test words.

3. Control words (e.g. 'rain', 'tail', 'real'). These words were actually Analogous and Common Letter test words for a different clue word from that being presented on a given trial. The Control words were intended to provide a stringent test of the use of analogy, as each Analogous test word was thus given twice over the experiment as a whole, once when it could be read by analogy, and another time when it could not. If analogies can be used to read new words, the Analogous words should only be read correctly when the correct clue word is given, and should be read incorrectly when given as Control words for a different clue word. A full list of all the words used is given in Table 6.4 (overpage).

To counterbalance the order of the word sets and conditions, the children were split into 3 groups of 12 matched for age and reading age. The sets of words were paired into three sets of two clue words and their associated test words, these sets being given in different conditions on separate days. The pairings were respectively the 'beak' and 'hark' words, the 'rail' and 'seen' words, and the 'coat' and 'skin' words. Each group received the words and conditions in different orders which were varied in two 3 x 3 Latin squares.

Table 6.4

Full list of words used - Experiment 2

<u>Clue</u>	<u>Beginning</u>	<u>End</u>	<u>Common Letter</u>
beak	bean	peak	lake
	bead	weak	bask
	beat	speak	bank
hark	harp	lark	hawk
	harm	bark	hair
	hard	dark	hear
rail	rain	tail	real
	raid	hail	lain
	raise	sail	pairs
seen	seed	queen	nest
	seem	green	nose
	seek	keen	send
coat	coach	float	cast
	coast	boat	cost
	coal	goat	cart
skin	skip	chin	silk
	skim	pin	pink
	skill	win	sign

Note. The Control words given varied between children, but were always one Beginning Analogous word, one End Analogous word, and one Common Letter word from a different clue word to that for which they acted as controls. These groupings are given by reading across Table 6.4 horizontally (e.g. 'bean', 'peak', and 'lake' would be one possible set of Control words for the clue word 'rail'). Over the whole experiment, all the Analogous and Common Letter words acted as Control words an equal number of times.

Predictions

If children can make analogies between the spelling patterns in words when reading aloud, they should read more Analogous words correctly in the Beginning and End conditions, where analogies can be made from the clue words, than in the No Clue condition, where analogies cannot be made. Furthermore, if children can make analogies between the clue and test words, more Analogous words should be read correctly in the Beginning and End conditions than Common Letter and Control words, but there should be no difference between the

different wordtypes in the No Clue condition.

Results

The mean number of words read correctly is given in Table 6.5, separated for readers and non-readers. The table shows that more Analogous words than Common Letter and Control words were read correctly in the Beginning and End conditions, but not in the No Clue condition. This suggests that analogyes were being made.

Table 6.5

Mean number of words read correctly in experiment 2 out of 6

<u>Wordtype</u>			
<u>Condition</u>	<u>Analogous</u>	<u>Common Letter</u>	<u>Control</u>
<u>Group</u>			
<u>Readers</u>			
Beginning	1.95 (1.53)	1.14 (1.08)	1.05 (1.33)
End	3.50 (1.97)	1.00 (1.02)	1.41 (1.44)
No Clue	1.32 ^a (1.43)	1.00 ^b (0.98)	0.77 (0.87)
<u>Non-scorers</u>			
Beginning	0.62 (1.26)	0.38 (1.12)	0.08 (0.28)
End	1.62 (1.61)	0.08 (0.28)	0.00 (0.00)
No Clue	0.08 ^a (0.28)	0.31 ^b (0.63)	0.08 (0.28)

Note. Standard deviations in parentheses.
^aFor the No Clue condition the Analogous scores refer to the Analogous Beginning words.
^bFor the No Clue condition the Common Letter scores refer to the Analogous End words.

As the results for the non-readers were not normally distributed (virtually no Common Letter or Control words were read), the data for the two groups were analysed separately.

Readers

To see whether analogies were being made by the readers, a 3 x 3 x 3 (Order group x Condition (Beginning, End and No Clue) x Wordtype (Analogous, Common Letter and Control)) Anova was performed with repeated measures on Condition and Wordtype. The dependent variable was the number of words read correctly. If analogies were being made, an interaction between Condition and Wordtype would be predicted. More Analogous words should be read correctly in the Beginning and End condition than Common Letter or Control words, but this should not occur in the No Clue condition. The full Anova table is given in Table 6.6.

Table 6.6

Anova on the number of words read correctly in Experiment 2: Readers

	Sum of Sq.	d.f.	Mean Sq.	F	P.
1. Order (O)	26.88	2	13.44	2.79	n.s.
Error	91.63	19	4.82		
2. Condition (C)	30.27	2	15.14	19.69	0.001
C x O	5.68	4	1.42	1.85	n.s.
Error	29.22	38	0.77		
3. Wordtype (W)	63.80	2	31.90	25.10	0.001
W x O	13.96	4	3.49	2.75	0.05
Error	48.30	38	1.27		
4. C x W	29.42	4	7.36	4.85	0.005
C x W x O	5.04	8	0.62	0.42	n.s.
Error	115.26	76	1.52		

The Anova showed a significant main effect of Condition ($F_{(2,38)} = 19.69, p < 0.001$). Tukey's post-hoc tests showed that

significantly more words were read correctly in the End condition than in the Beginning condition or in the No Clue condition (1.97 vs. 1.38 and 1.03 respectively, $p's < 0.01$). The number of words read correctly in the Beginning condition did not differ significantly from the number of words read correctly in the No Clue condition. There was also a significant main effect of Wordtype ($F(2,38) = 25.10$, $p < 0.001$). This was caused by significantly more Analogous words being read correctly than Common Letter or Control words (2.26 vs. 1.05 and 1.08 respectively, $p's < 0.01$, Tukey's).

There were two significant interactions. Most importantly, a significant interaction between Condition and Wordtype ($F(4,76) = 4.85$, $p < 0.005$) was found. This suggests that analogies were being made. Post-hoc tests (Newman-Keuls) showed that the interaction was due to performance on the Analogous words in the End condition being significantly better than performance on the Analogous words in the Beginning and No Clue conditions ($p < 0.01$). Performance on the Analogous words was also significantly better than performance on the Common Letter and Control words in the End condition only ($p < 0.05$). This shows that analogies were being made between the ends of words. Performance on the Analogous words in the Beginning condition was not significantly different from performance on the Common Letter or Control words.

As mentioned above, the Control words were included to provide a stringent test of an analogies hypothesis. The Control words were actually Analogous and Common Letter words taken from different clue words than the ones to which they acted as controls. This means that the Analogous words were being given twice over the experiment as a whole, once when they could be read by analogy to the clue words and

the other time when they could not. If children can use analogies to read new words, they should be able to read the Analogous words only when the relevant clue word is present. When analogies cannot be made from the clue word to the Analogous words, the children should not be able to read the Analogous words correctly. Thus in the Beginning and End conditions, significantly more Analogous words than Control words should be read correctly, but this should not happen in the No Clue condition. This pattern of results was found for the End condition, and provides strong evidence that children can use analogies between the spelling patterns at the ends of words to read new words aloud.

The differences between the number of Common Letter words read correctly and the number of Control words read correctly was not significant in any of the conditions, whether a clue word was present or not. It was mentioned earlier that the clue words might help the children to read the Common Letter words to some extent, since some of the grapheme-phoneme correspondences in the clue words were the same as those in the Common Letter words. The failure to find any significant difference between reading the Common Letter words and reading the Control words suggests that the children were not helped by the individual grapheme-phoneme correspondences in the clue words.

A significant interaction was also shown between Wordtype and Order ($F(2,38) = 2.75, p < 0.05$); this was not predicted. The interaction suggests that performance on the different wordtypes differed depending on the order in which they were received. Post-hoc tests (Newman-Keuls) showed that significantly more Analogous words were read correctly in the experiment as a whole by the children who received the No Clue condition first than by the children who received the Beginning and the End conditions first (3.29 vs. 1.81

and 1.75 respectively, $p's < 0.01$). There were no significant differences between any of the other wordtypes. This result is difficult to interpret.

Thus the results for the readers show that children can make analogies between the spelling patterns at the ends of words, and can use these analogies to read new words which they cannot read in the absence of a model from which analogies can be made. The effect is not found for analogies between the beginnings of words, however. Although performance on the Analogous words in the Beginning condition was better than performance on the Analogous Beginning words in the No Clue condition, providing some indication that analogies between the beginnings of words might be made to a limited extent, the difference was not significant. We will now examine the performance of the non-readers.

Non-readers

For the non-readers, a Friedman Two-way analysis of variance by ranks was performed for each condition on the number of words read correctly. If analogies were being made by the non-readers, then performance on the Analogous words should be significantly better than performance on the Common Letter and Control words in the Beginning and End conditions, but not in the No Clue condition. The analysis showed that there was a significant difference between the different wordtypes in the End condition only ($\chi^2(2, N = 14) = 5.99$, $p = .05$). Post-hoc testing with the Wilcoxon matched-pairs signed ranks test showed that the Analogous test word score was significantly greater than the Common Letter and Control word scores, as predicted by an analogy explanation ($T = 0$, $N = 9$, $p < .002$). So, some children only on the verge of reading can make analogies between

the spelling patterns at the ends of words.

Discussion of Experiment 2

It has been shown that young children can use analogies between the spelling patterns at the ends of words to read new words aloud. Children who are both on the verge of reading and already beginning to read make a significant number of analogies between the rimes in words - the part of the word represented by the vowels and terminal consonant. Children's ability to make analogies between the spelling patterns at the beginnings of words when reading aloud remains uncertain, since while some indication of such an effect was found, it was not significant. This shows that there is a strong End effect in making analogies in reading aloud.

Children's ability to use the spelling-sound relation represented by a known (clue) word to make inferences about the pronunciation of a new word which has the same spelling pattern at the end may reflect the salience of rhyme for young children. Many of the studies discussed in Chapter 4.4.i. and 4.4.ii. showed that young children were skilled at recognising rhyming words in tasks such as forced-choice recognition and odd word out (e.g. Lenel and Cantor, 1980; Knafle, 1974; Bradley and Bryant, 1978). If rhyme has a special role in analogies between the spelling patterns in words, this could explain the strong End effect found. Rhyming skills are generally superior to skills of alliteration in young children before they learn to read (Bradley and Bryant, 1983; 1985).

Furthermore, skill in rhyming is an important predictor of later reading development (Bradley and Bryant, 1983, 1985; Lundberg, Olofsson and Wall, 1980; Ellis and Large, 1986). This raises the

interesting possibility that skill in rhyming is important for later reading development because of its connection with analogy. Rhyming involves categorising words on the basis of sound, as words which rhyme are basically categories of words which have a common sound at the end. Analogy requires children to categorise words on the basis of spelling pattern, and these graphemic categorisations must then be used to make predictions about sound. In many cases, however, these two kinds of category will be identical: words which rhyme are often spelled the same at the end. So rhyming may be intimately connected with making analogies between the ends of words in reading. This possibility will be pursued further in the next chapter.

Discussion of Experiments 1 and 2

Experiments 1 and 2 have shown that young children are able to make analogies in reading new words. However, in Experiment 1, the children were better at choosing words which were analogous at the beginnings than at choosing words which were analogous at the ends, suggesting that analogies between the beginnings of words were easier than analogies between the ends of words. In Experiment 2 the opposite was true. A strong End effect was found, suggesting that analogies between the ends of words were easier than analogies between the beginnings of words. It was suggested that the End effect may arise because of an intimate connection between analogies and rhyming skills.

One possible explanation for this difference between the two experiments is that it is due to the different modes of presenting the task rather than due to differences in the use of analogy. In Experiment 1, the children had to use visual information to select the correct spelling patterns of words which sounded similar, whereas

in Experiment 2 the children had to produce pronunciations for words which shared similar spelling patterns. Recognising similarities in spelling may be easier for words which look the same at the beginning, as reading operates from left to right. However, assigning common pronunciations on the basis of common spellings may be easier for sound patterns at the ends of words, given the salience of rhyme for young children. Further research is needed to establish whether this explanation is the correct one.

The results of the non-readers in Experiments 1 and 2, although only of a preliminary nature, are especially exciting. The fact that children on the verge of reading made analogies between the spelling patterns in words suggests that analogy is a strategy which is available very early on in a child's dealings with print. This result supports the findings of a study by Baron (1977) discussed in Chapter 3.3.i., which suggested that kindergarteners taught words such as 'ed' and 'red' could successfully read new words such as 'bed'.

A study is now required which looks in more detail at the development of the use of an analogy strategy in reading. We do not know whether analogy is used from the very beginning in reading acquisition, or whether there is a developmental increase in its use. We also do not know whether analogy use is related to other factors known to be important in reading development, such as rhyming skills. To examine these questions, a study is required which (a) compares the reading behaviour of children of different reading levels on the same words, and (b) assesses the relationship between analogy use and performance on tests of phonological awareness, such as a test of rhyming and alliteration skill and a test of phoneme deletion. Such a study is presented in Chapter 7.

CHAPTER SEVENAN EXAMINATION OF DEVELOPMENTAL DIFFERENCES IN THE USE OFANALOGIES IN READING

Having shown that children at the very beginning stages of learning to read can make analogies between the spelling patterns in words, we must ask whether the use of an analogy strategy in reading develops as reading skill increases. Very little is known about the development of the use of analogy in reading. It was shown in Chapter 3.2.i. that Marsh and his co-workers (Marsh, Desberg and Cooper, 1977; Marsh, Friedman, Welch and Desberg 1980a; Marsh, Friedman, Desberg and Saterdahl, 1981) have made the claim that analogy is a strategy which only emerges in the final stage of learning to read. However, the evidence which they use to support this claim is ambiguous. The opposite position is adopted by Baron (1977), who claims that analogies can be used to read new words even by kindergarteners. Again, however, the evidence for this claim is open to alternative interpretations. The positions of Marsh et al. and of Baron will now be briefly recapped.

Marsh and his fellow workers argued that analogy was the final strategy to emerge in reading development. They claimed that children first decode words by a strategy of guessing from context, without any reference to the orthography of the words. This is followed by a stage when children use some of the orthographic information in a word, such as initial letter, to supplement context-based guessing, and then a stage where children use grapheme-phoneme correspondences to decode new words on a letter-by-letter basis. It is only after this grapheme-phoneme conversion stage that children become capable

of using analogies to read new words.

Marsh and his co-workers have conducted a number of experiments in support of this developmental claim, all of which examined the strategies which children use to decode nonsense words. Their studies were based on the rationale that the pronunciations given to nonsense words can be used to determine which strategy a child is using in reading. A child in stage 3 asked to read a nonsense word like 'puscle' will read it using grapheme-phoneme correspondences, and will give the pronunciation 'puskle', whereas a child in stage 4 of the developmental sequence will read 'puscle' by analogy to 'muscle', giving the alternative pronunciation 'pussle'. Marsh and his co-workers have reported a number of experiments which showed that the number of analogous pronunciations given to nonsense words increased significantly with age, with a corresponding decline in the number of responses based on grapheme-phoneme correspondences.

However, as discussed in Chapter 3.2.i., this rationale is only meaningful if all the children know the words which are meant to form the basis of the analogies. If a seven year old child cannot read a word like 'muscle' and a ten year old child can, then the seven year old child will appear to be unable to use analogy in any experiments using this design. Marsh and his co-workers did not ensure that the younger subjects knew the real words which were meant to form the basis of the analogies in any of their studies, even though these words were generally quite difficult (e.g. 'muscle', 'piety', 'soldier'). Thus the developmental increase in the use of analogy with age which they consistently reported may have been due to the younger children knowing fewer of the real words on which analogies were meant to be based, rather than to a real developmental increase

in the use of analogies in reading.

The claim of Baron (1977) is in sharp contrast to the claim of Marsh et al. Baron argued that analogy is a natural strategy to use in decoding new words, and is available even to kindergarteners (see Chapter 3.3.i.). He reported an experiment in which kindergarteners who were taught to read words such as 'bed' later successfully decoded new analogous words like 'red', but not new words which also had two grapheme-phoneme correspondences in common with the taught word, like 'bad'. However, Baron's results were hard to interpret, as the children learning 'bed' were also taught the segment '-ed' (necessary for reading 'red'), but not the segment '-ad' (necessary for reading 'bad'). This means that they had been taught more information relevant to the new analogous words than to the new non-analogous words, which could have explained their superior decoding of the analogous words.

This brief review makes it clear that our knowledge about the development of the use of analogies in reading is extremely limited. It has not been shown that analogy is available from the earliest stages of learning to read, as Baron's position would predict, and nor has it been shown that analogy is a sophisticated strategy only found in the final stage of reading, as Marsh and his co-workers would predict. A study is needed which compares the use of analogy by children of different reading ages in conditions where all the children have the real-word basis for making analogies available to them. Furthermore, it is important that the study does not rely solely on nonsense words, which may encourage the use of unusual strategies in reading.

In Experiment 3, children aged from 5 to 8 years played the word

game used in Experiment 2, but the design of the study was expanded to include nonsense words. As before, the children had to read words and nonsense words which were either analogous or non-analogous to 'clue' words such as 'beak'. The clue word was present throughout each session so that all the children had the basis for making analogies available to them, although no instruction about how to use the clue word was given.

The same test words were given to all the children, so that any developmental differences which might be found could not be due to the nature of the words being used. To eliminate the problem of differential initial knowledge of the test words (the older children may have already known some of the test words and the younger children may not), Pretest scores were compared to Analogy test (post-test) scores. As in Experiments 1 and 2, the study also asked whether analogies would be made between the beginnings of words (beak-bean) as well as between the ends of words (beak-peak).

A final extension of the study was to include tests of phonological awareness (a test of rhyming and alliteration, and a test of phoneme deletion). These tests were included because it was felt that the use of analogies in reading might be strongly related to rhyming skills. It was clear from the literature reviewed in Chapter 4.4.iii. and 4.4.iv. that measures of rhyming are strongly related to later reading development. Sets of rhyming words are in effect categories. If a child realises that 'mat', 'hat', 'bat' and 'cat' rhyme, she is dealing with a category of words which have a common sound. The same is true of alliteration, as words which begin with a common sound also form categories. The evidence on rhyming and alliteration suggests very strongly that preschool children have

formed many such categories.

These categories are potentially important as far as reading goes because when a child has to learn about spelling patterns she will encounter another kind of category, orthographic categories, which consist of words which share a common spelling pattern. These words will often have a sound in common too, and thus will map onto the rhyming categories that the child has already formed. It seems extremely likely that experience with the first kind of category (rhyme and alliteration) will play a significant role in helping the child to form the second kind of category (orthographic).

So even before they learn to read, young children put words into categories based on sound, and their ability to do so predicts their success in learning to read. A child who could further learn that common orthography predicts common sounds would in principle be able to learn to recognise and use strings of letters to decipher new words by reference to known words, in other words to read new words by analogy to known words. A strong relationship between rhyming skill and analogical ability might thus be predicted.

In order to establish a specific relation between rhyming and analogies, it is necessary to show that analogy is more strongly related to rhyming than to other measures of phonological awareness. One measure of phonological awareness which might provide a good test of this is phoneme deletion. It was shown in Chapter 4.1. that segmentation and blending skills are required to make an analogy in reading. To make an analogy between 'beak' and 'peak', the child must delete the 'b' from 'beak' and blend 'p' in its place; similarly to make an analogy between 'beak' and 'bean', the child must delete the 'k' from 'beak' and blend 'n' in its place. Thus tests of initial and

final phoneme deletion may well also be significantly related to analogical ability. A strong relationship between initial phoneme deletion and analogies between the ends of words, and between final phoneme deletion and analogies between the beginnings of words, might be expected. However, if there is a special and important connection between analogy use and rhyming ability, then this relationship should be significantly stronger than the relationship between analogy use and phoneme deletion.

Experiment 3: Analogies in Reading: A Developmental Study

The aim of Experiment 3 was to compare the use of analogies in reading by children at three different reading levels, and to see whether the use of analogies in reading was related to skills such as rhyming and phoneme deletion. The method used was basically an expansion of the wordgame used in Experiment 2. Changes made in the procedure are outlined below.

Method

Subjects

The subjects were drawn from the infant classes of a local primary school. The children were divided into three groups based on performance on the Schonell Graded Word Reading Test. The youngest group did not score on the test, and were not yet reading. The children were also given the British Picture Vocabulary Scales as a measure of verbal ability. Ages, reading levels, and BPVS scores for the groups are given in Table 7.1 (overpage).

Table 7.1

Subject groups: Age, Reading Age, and Verbal Skills

		<u>Chronological Age</u>		<u>Reading Age</u>		<u>BPVS</u>	
<u>Group</u>	<u>N</u>	<u>Mean</u>	<u>S.D.</u>	<u>Mean</u>	<u>S.D.</u>	<u>Mean</u>	<u>S.D.</u>
1	18	5;4	3.1	6;0	0.0	104.7	15.1
2	18	6;10	8.9	6;10	1.1	96.8	13.3
3	17	7;1	8.7	7;4	3.2	100.6	12.7

Procedure

Design

The design was very similar to that used in Experiment 2, as the same wordgame was used, and so were the same words and wordtypes. However, the inclusion of nonsense words necessitated an expansion of the design, and the use of children at three different reading levels required prior knowledge of the words being used to be scored on a Pretest. The children were seen seven times in all, once for a Pretest and then for six Analogy sessions. The changes made in the experimental design are outlined below.

Pretest

The children were first pretested on all the words and nonsense words being used. The words were presented for reading in two randomised lists. The first list consisted of the analogous and non-analogous words being used mixed with other real words suitable for six-seven year old readers. The second list consisted of the analogous and non-analogous nonsense words being used mixed with

other nonsense words. The nonsense words were derived by changing one letter of the real analogous and non-analogous and filler words used in the first list. There were 72 words in each list.

Analogy Sessions

The children were seen six times in six different Analogy sessions, each session being given on a different day. A different condition was given in each session, but the procedure in each session was the same, and identical to that used in Experiment 2. In each Analogy session the children were shown a written clue word (e.g. 'beak'), and were asked to read seven test words, which were either analogous or non-analogous to the clue word. The test words were either real words or nonsense words, the nonsense words being derived from the real words by changing one letter, so that the orthographic sequence required for the analogy remained intact (e.g. 'beal', 'neak'). The clue words and their associated test words were printed on white cards as before, and as previously were presented for reading in a randomly-determined order.

Conditions

As in Experiment 2, the children played the word game in three conditions, these being given twice: once for the real words and once for the nonsense words. The three conditions were the same as in Experiment 2, namely Beginning, where the Analogous words were analogous to the clue word at the beginning; End, where the Analogous words were analogous to the clue word at the end; and No Clue, where no clue word was presented. An example using a different set of words was given before each condition.

Words

The children were given three Analogy sessions with real words and three Analogy sessions with nonsense words. The real words used were identical to the words used in Experiment 2, but only some of the words for each wordset were used. The nonsense words were derived from the real words by changing one letter in a way that preserved the orthographic sequence relevant to the analogy. Thus a word like 'bean' would be changed to 'beal', and a word like 'peak' would be changed to 'neak'. The same procedure was followed in the case of the Common Letter words. For these words the nonsense words retained three letters in common with the clue words, so a word like 'bask' would be changed to 'bawk'.

Wordtypes

As in Experiment 2 there were three types of test words, the same types of words being given in both the real word and the nonsense word sessions. The three wordtypes were: 1. Analogous words (two given), which shared the same orthographic sequence as the clue words at either the beginning (e.g. 'beak-bean' or 'beak-beal'), or the end ('beak-peak' or 'beak-neak'); 2. Common Letter (CL) words (two given), which also had three letters in common with the clue words, but for which the shared letters were not in sequence (e.g. 'beak-bask' and 'beak-bawk'); and 3. Control words (three given), which were the Analogous and Common Letter words for a different clue word from the one to which they acted as controls (e.g. 'beak' - 'rain', 'tail', 'real'; or 'beak' - 'rait', 'kail', 'roal'). As in Experiment 2 the words were printed in black type 1/2" high on 4" x 6" white cards, and the Common Letter words were matched in frequency to the Analogous words using the Carroll, Davies and Richman (1971)

norms. The words and nonsense words used are given in Table 7.2.

Table 7.2

Full list of words and nonsense words used

<u>Clue word</u>	<u>Beginning</u>	<u>End</u>	<u>Common Letter</u>
beak	bean (beal) bead (beap)	peak (neak) weak (feak)	lake (pake) bask (bawk)
hark	harp (harf) harm (harn)	lark (sark) bark (tark)	hawk (howk) hair (haik)
rail	rain (rait) raid (raim)	tail (kail) hail (bail)	real (roal) lain (laik)
seen	seed (seel) seem (seet)	queen (peen) green (reen)	nest (nase) nose (seng)
coat	coach (coad) coast (coan)	float (poat) boat (roat)	cast (cait) cost (cort)
skin	skip (skib) skim (skif)	chin (hin) pin (lin)	silk (soik) pink (tink)

Note. Nonsense words in parentheses.

In order to counterbalance the order of receiving the word sets and conditions, the three groups of children were split into three sub-groups of six (or two groups of six and one of five for Group 3) matched for age and reading age. The word sets were paired so that two clue words and their associated test words were given in any one session. The pairings were the 'beak' and 'hark' words, the 'rail' and 'seen' words, and the 'coat' and 'skin' words, as before. The same pairings were used for the nonsense words. Children received the words sets and conditions in different orders according to two 3 x 3 Latin squares. For Group 3, where there were 17 subjects instead of 18, the design was not fully balanced. In addition, the sub-groups for each reading level were split in half, three children in each sub-group receiving the nonsense words first and three children in each sub-group the real words first in all three conditions.

Post-tests

Following the experiment, the children were given the WISC digit span test as a measure of memory, and also a number of tests of phonological awareness. These were the Bradley and Bryant 'odd man out' test of rhyming and alliteration, and a test of initial and final phoneme deletion. The Bradley and Bryant test requires the child to select the 'odd one out' of sets of four words, which either differ in first sound (rock, rod, rock, box), middle sound (mop, hop, tap, lop), or final sound (cat, hat, rat, fan). Ten sets of four words are presented for each type of oddity. The words used are given in the Appendix. Bradley and Bryant (1983) have shown that performance on these tests is a strong predictor of later reading development. The phoneme deletion test used was an adaptation of that used by Content, Morais, Alegria and Bertelson (1982), in which puppets speak a 'secret language'. To speak the secret language, it is necessary to delete either the initial (bead-ead) or the final (bead-bea) phoneme from words. One puppet (operated by the experimenter) says a word, and the other (operated by the child) repeats it without the relevant phoneme. The words given here were the Analogous test words used in the study, making two sets of 24 words for each child.

Predictions

If children can make analogies between the spelling patterns in words, more Analogous words should be read correctly at Analogy test than at Pretest in the Beginning and End conditions, but the number of Common Letter and Control words read correctly should not improve from Pretest to Analogy test. If children at all reading levels are able to make analogies, then this pattern of results should be found

in all three groups. However, if analogy is a sophisticated strategy which is not available until a late stage of learning to read, or if there are strong developmental differences, then group differences in the use of analogy or in the number of analogies made would be predicted.

Results

The results for the children who could read (groups 2 and 3) were analysed separately from the results of the non-readers (group 1), whose scores were not normally distributed. The results for groups 2 and 3 will be reported first.

Groups 2 and 3

A comparison of the mean number of words and nonsense words read correctly on the Analogy sessions compared to the Pretest is given in Tables 7.3 and 7.4 (overpage).

As the tables show, the increase from Pretest to Analogy test in the number of words read correctly is of a much greater magnitude for the Analogous words than for the Common Letter and Control words in the Beginning and End conditions, but not in the No Clue condition. This effect occurs both for words and for nonsense words, and seems to be equally strong at both reading levels.

Table 7.3

Mean number of words and nonsense words read correctly
by wordtype out of 6: Group 2

<u>Condition</u>	<u>Test</u>	<u>Wordtype</u>		
		<u>Analogous</u>	<u>Common Letter</u>	<u>Control</u>
<u>WORDS</u>				
Beginning	Pre.	0.28 (0.57)	0.33 (0.49)	0.89 (1.18)
	Anal.	2.22 (1.48)	1.06 (1.00)	1.39 (1.24)
End	Pre.	0.94 (0.94)	0.56 (0.86)	0.72 (0.83)
	Anal.	3.00 (1.28)	0.78 (0.88)	1.22 (1.31)
No Clue ^a	Pre.	0.44 (0.92)	0.67 (0.69)	0.56 (0.62)
	Anal.	0.72 (0.89)	1.00 (1.00)	1.33 (1.14)
<u>NONSENSE WORDS</u>				
Beginning	Pre.	0.50 (0.79)	0.17 (0.38)	0.33 (0.69)
	Anal.	1.61 (1.33)	0.56 (0.70)	1.00 (0.97)
End	Pre.	0.44 (0.78)	0.06 (0.24)	0.44 (0.92)
	Anal.	3.00 (1.14)	0.33 (0.60)	0.50 (0.99)
No Clue ^a	Pre.	0.22 (0.43)	0.44 (0.86)	0.44 (0.98)
	Anal.	0.72 (1.13)	0.61 (0.78)	1.11 (1.08)

Table 7.4

Mean number of words and nonsense words read correctly
by wordtype out of 6: Group 3

		<u>Wordtype</u>		
<u>Condition</u>	<u>Test</u>	<u>Analogous</u>	<u>Common Letter</u>	<u>Control</u>
<u>WORDS</u>				
Beginning	Pre.	1.06 (0.83)	1.12 (0.70)	2.00 (2.06)
	Anal.	2.71 (1.26)	1.76 (0.90)	2.18 (2.21)
End	Pre.	1.47 (1.07)	1.41 (1.06)	1.88 (1.66)
	Anal.	3.65 (0.86)	1.35 (1.22)	3.06 (1.71)
No Clue ^a	Pre.	1.41 (1.06)	1.76 (1.38)	1.88 (1.62)
	Anal.	1.76 (1.38)	2.18 (0.95)	2.41 (1.50)
<u>NONSENSE WORDS</u>				
Beginning	Pre.	0.82 (0.95)	0.24 (0.56)	0.88 (0.92)
	Anal.	2.18 (1.29)	0.86 (1.29)	1.18 (1.38)
End	Pre.	0.76 (0.79)	0.59 (0.62)	0.71 (1.05)
	Anal.	3.06 (1.19)	0.71 (1.10)	1.35 (0.93)
No Clue ^a	Pre.	0.76 (0.87)	0.59 (1.11)	0.71 (1.30)
	Anal.	1.06 (1.14)	1.18 (1.13)	1.82 (1.38)

Note. Analogous and Common Letter test word scores were multiplied by 3/2 to bring them into line with Common Letter word scores.

Standard deviations in parentheses.

^a In the case of the No Clue condition, the Analogous word figures refer to the Analogous Beginning words, and the Common Letter figures to the Analogous End words

In order to see whether our predictions had been confirmed in the way suggested by Tables 7.3 and 7.4, and to check that this pattern of results held for nonsense words as well as real words, a $3 \times 2 \times 2 \times 3 \times 2 \times 3$ (Order group $\times$ Reading Level (Groups 2 and 3) $\times$ Meaning (Words vs. Nonsense words) $\times$ Condition (Beginning, End and No Clue) $\times$ Test (Pretest vs. Analogy test) $\times$ Wordtype (Analogous, Common Letter and Control)) analysis of variance was performed, with repeated measures on Meaning, Condition, Test and Wordtype. The number of words read correctly was taken as the dependent variable.

If analogies were being made, an interaction between Condition, Test and Wordtype would be predicted, as more Analogous words should be read correctly at Analogy test than at Pretest in the Beginning and End conditions but not in the No Clue condition, and the number of Common Letter and Control words read correctly should not improve from Pretest to Analogy test. If analogies were made differently for real words and for nonsense words, or if analogies were only used to read real words and not to read nonsense words, an interaction between Meaning, Condition, Test and Wordtype would be predicted, as the number of Analogous words read correctly at Analogy Test in the Beginning and End conditions should differ for words and nonsense words. If analogies were made differently by children at different reading levels, an interaction between Reading Level, Condition, Test and Wordtype would be predicted, as more analogies should be made by children in group 3 than by children in group 2. Finally, if analogies were made differently for real and for nonsense words depending on reading level, an interaction between Reading Level, Meaning, Condition, Test and Wordtype would be predicted. The full Anova table is given in the Appendix, as it is too long to present here.

The main effects shown in the Anova will be discussed first. The main effect of Reading Level ($F(1,29) = 9.84, p < 0.005$) was caused by the children in group 3, who were six months ahead of the children in group 2 in reading, reading more words correctly than the children in group 2 (1.51 vs. 0.85). The main effect of Meaning ($F(1,29) = 69.03, p < 0.0001$) was caused by the children reading more words correctly than nonsense words (1.46 vs. 0.88). The main effect of Condition ($F(2,58) = 3.85, p < 0.05$) was caused by significantly more words being read correctly in the End condition than in the No Clue condition (1.31 vs. 1.09, $p < 0.05$, Tukey's). The number of words read correctly in the Beginning condition (1.11) did not differ significantly from the number of words read correctly in either the End condition or the No Clue condition. The main effect of Test ($F(1,29) = 145.54, p < 0.0001$) was caused by more words being read correctly at Analogy test (1.56) than at Pretest (0.78). Finally, the main effect of Wordtype ($F(2,58) = 31.53, p < 0.0001$) was caused by significantly more Analogous words being read correctly than Common Letter words (1.43 vs. 0.84, $p < 0.01$) or Control words (1.43 vs. 1.25, $p < 0.05$) (Tukey's). The number of Control words read correctly was significantly greater than the number of Common Letter words read correctly.

There were a number of significant interactions. If analogies were being made, a three-way interaction between Condition, Test and Wordtype would be predicted. Such an interaction was found. However, the two-way interactions will be examined first, in the order in which they appear in the Anova.

The interaction between Meaning and Reading Level was significant ($F(1,29) = 15.43, p < 0.0005$). Post-hoc tests

(Newman-Keuls) showed that the interaction was difficult to interpret. The children in both groups read significantly more real words than nonsense words correctly (Non-readers: 1.00 vs. 0.69; Readers 1.95 vs. 1.07; $p's < 0.01$), and the readers read significantly more words of each type correctly than the non-readers ($p's < 0.01$). Hence while the interaction suggests that more analogies were made to the real words by the readers, this cannot be confirmed.

The interaction between Condition and Test was also significant ($F(2,58) = 20.18, p < 0.0001$). Post-hoc tests (Newman-Keuls) showed that significantly more words were read correctly in the End condition than in the Beginning condition at Analogy test (1.82 vs. 1.53, $p < 0.01$), and significantly more words were read correctly in the Beginning condition than in the No Clue condition at Analogy test (1.53 vs. 1.31, $p < 0.01$). There were no significant differences between the different conditions at Pretest. So the interaction arose from superior performance in the Beginning and End conditions at Analogy test compared to the No Clue condition.

The Anova also showed a significant interaction between Meaning and Wordtype ($F(2,58) = 5.46, p < 0.01$). Newman-Keuls tests indicated that significantly more real words than nonsense words were read of all types ($p's < 0.01$). However, significantly more Analogous and Control real words were read correctly than Common Letter words (1.63 and 1.61 vs. 1.15, $p's < 0.01$), whereas for the nonsense words significantly more Analogous words were read correctly than Control words (1.22 vs. 0.88, $p < 0.01$), and significantly more Control words were read correctly than Common Letter words (0.88 vs. 0.52, $p < 0.01$). Hence the interaction was caused by as many Control real words being read correctly as Analogous real words.

A significant interaction between Condition and Wordtype was also found ($F(4,116) = 15.25, p < 0.0001$). Post-hoc tests (Newman-Keuls) showed that significantly more Analogous words were read correctly in the End condition than in the Beginning condition (2.01 vs. 1.41, $p < 0.01$), and significantly more Analogous words were read correctly in the Beginning condition than in the No Clue condition (1.41 vs. 0.85, $p < 0.01$). The number of Control and Common Letter words read correctly did not differ between any of the conditions. Thus the interaction was caused by performance on the Analogous words differing with condition. Most Analogous words were read correctly in the End condition, fewer were read correctly in the Beginning condition, and fewest Analogous words were read correctly in the No Clue condition.

There was also a significant interaction between Test and Wordtype ($F(2,58) = 63.03, p < 0.0001$). Post-hoc tests (Newman-Keuls) showed that the number of words read correctly improved significantly from Pretest to Analogy test for all the wordtypes (p 's < 0.01). However, the number of Control words read correctly at Pretest was significantly greater than the number of Analogous and Common Letter words read correctly at Pretest (0.96 vs. 0.72 and 0.67 respectively, p 's < 0.01). At Analogy test, significantly more Analogous than Control words were read correctly (2.13 vs. 1.54, $p < 0.01$), and significantly more Control than Common Letter words were read correctly (1.54 vs. 1.00, $p < 0.01$). Thus the interaction was caused by a significantly greater improvement on the Analogous words compared to the other wordtypes.

We will turn now to the three-way interactions. As stated above, if analogies were being made, an interaction between Condition, Test

and Wordtype would be expected, as performance on the Analogous words in the Beginning and End conditions should improve from Pretest to Analogy test, but no such improvement should be found in the No Clue condition, where no basis for analogy was provided. Such an interaction was found ($F(4,116) = 17.91, p < 0.0001$). The number of words read correctly in each condition is shown in Table 7.5 (overpage).

Post-hoc tests (Newman-Keuls) showed that significantly more Analogous words were read at Analogy test than at Pretest in the Beginning and End conditions ($p's < 0.01$), but not in the No Clue condition. This shows that analogies were being made. For the Common Letter words, the only significant improvement found was in the Beginning condition. This suggests that the children were using some of the grapheme-phoneme correspondences in the clue words to help them in reading the Common Letter words in this condition. It is not clear why this did not occur in the End condition as well. However, significantly more Analogous words than Common Letter words were read correctly at Analogy test in the Beginning condition ($p < 0.01$). This means that analogy had a much stronger effect than common grapheme-phoneme correspondences.

Finally, the number of Control words read correctly improved significantly in all the conditions ($p's < 0.01$). This result was not predicted. However, significantly fewer Control words than Analogous words were read correctly at Analogy test in the Beginning and End conditions ($p's < 0.01$), which shows that the children read significantly more words correctly when analogies could be used. In contrast, more Control words than Analogous words were read correctly in the No Clue condition. Hence the children improved to a small but

Table 7.5

Number of words and nonsense words read correctly

<u>Condition</u>	<u>Test</u>	<u>Wordtype</u>		
		<u>Analogous</u>	<u>Common Letter</u>	<u>Control</u>
Beginning	Pre.	0.66	0.46	0.97
	Anal.	2.17	1.00	1.43
End	Pre.	0.86	0.60	0.93
	Anal.	3.17	0.79	1.51
No Clue	Pre.	0.64	0.96	0.97
	Anal.	1.06	1.21	1.67

significant extent in reading the Control words in all the conditions, but improved on the Analogous words to a greater extent only when analogies could be made. This shows that the children made analogies from the clue words in reading.

Table 7.5 also indicates that it is easier to make analogies between the ends of words than between the beginnings of words. Newman-Keuls post-hoc tests confirmed that the number of analogies made between the ends of words was significantly greater than the number of analogies made between the beginnings of words ($p < 0.01$).

There was also a significant interaction between Test, Wordtype and Order ($F(4,58) = 3.55, p < 0.05$), which was not predicted. Post-hoc tests (Newman-Keuls) showed that this interaction arose because of performance on the Common Letter and Control test words, and not because of any differences in the number of analogies made by

the different Order groups. All three order groups read significantly more Analogous words correctly at Analogy test than at Pretest ($p's < 0.01$). However, the children in Order groups I and III (Beginning condition first and No Clue condition first respectively) also improved significantly on the Control test words at Analogy test compared to Pretest ($p's < 0.01$), whereas those in Order Group II (End condition first) did not. For the Common Letter words, there was no improvement from Pretest to Analogy test for Order Groups I and II, but the children in Order Group III read significantly more Common Letter words correctly at Analogy test than at Pretest ($p < 0.05$). This means that the Order effect was due to apparently random differences in performance on the Common Letter and Control words, and does not pose any problems for an analogies hypothesis. The order of receiving the conditions had no effect on the number of analogies made, as would be expected.

A significant four-way interaction was also found between Meaning, Condition, Test and Wordtype ($F(4, 116) = 5.26, p < .001$). Post-hoc tests (Newman-Keuls) showed that significantly more Analogous words were read correctly at Analogy test than at Pretest for both the real and nonsense words in both the Beginning and End conditions ($p's < 0.01$). So analogies were made in the same way for both real and nonsense words. However, significantly more real than nonsense Analogous words were read correctly at Analogy test in the Beginning condition (2.46 vs. 1.89, $p < 0.01$), while the number of real and nonsense Analogous words read correctly at Analogy test in the End condition did not differ (3.31 and 3.03 respectively). This suggests that more analogies were made between the beginnings of real words than between the beginnings of nonsense words, but that analogies were made between the ends of words to the same extent

whether the words were real or nonsense.

There were also some randomly-distributed differences between the Common Letter and Control real and nonsense words, which made the interaction difficult to interpret. The children read significantly more Common Letter real words correctly at Analogy test compared to Pretest in the Beginning condition (1.40 vs. 0.71, $p < 0.05$). No other improvements on the Common Letter real words or nonsense words were significant. For the Control words, all the improvements were significant at the 0.01 level except for the real Control words in the Beginning condition and the nonsense Control words in the End condition. These differences were small ones and do not have any obvious explanation. However, the four-way interaction was clearly not simply due to more analogies being made for the real words than for the nonsense words in the Beginning condition.

Two large interactions with Order occurred which seemed too complex to analyse. These were between Meaning, Condition, Test, Wordtype and Order ($F(4,116) = 2.08$, $p < 0.05$), and between Meaning, Condition, Test, Wordtype, Order and Reading Level ($F(8,116) = 2.10$, $p < 0.05$). Given the finding that the interaction between Test, Wordtype and Order arose from differences in the Common Letter and Control word scores, it seemed likely that these interactions with Order arose from similar random fluctuations, rather than from factors connected with analogical performance.

Finally, the Anova showed that the analogy effects were independent of reading level. If children at a later stage of reading development were better at using analogy than children at an earlier stage of reading development, an interaction between Condition, Test, Wordtype and Reading Level, or between Meaning, Condition, Test,

Wordtype and Reading Level would be predicted. Neither of these interactions approached significance ($F(4, 92) = 1.15$, and $F(4, 92) = 0.57$, respectively). The lack of an interaction with reading level is striking, as it shows that the ability to make analogies in reading is not related to reading level, at least in the initial stages of reading examined here. This finding is inconsistent with the developmental theory of analogy of Marsh and Desberg (1983). Younger readers are as capable of using analogy as older readers.

In order to examine this important conclusion further, Pearson product-moment correlations were calculated between the number of analogies made and both reading level and age. Analogies between the beginnings of words were calculated by subtracting Analogous word scores on the No Clue condition from Analogous word scores on the Beginning condition, as performance in the No Clue condition provides a baseline measure of reading the Analogous words. Analogies between the ends of words were calculated in the same way, by subtracting the Analogous word scores in the No Clue condition from the Analogous word scores in the End condition. This gave two measures of analogy use, AnlogB and AnlogE.

The AnlogB and AnlogE scores were then correlated with reading level and with age. If analogical ability was related to a child's developmental level, either in terms of chronological age or in terms of reading development, a significant correlation between analogy use and these measures would be expected. None of the correlations approached significance. Correlations of AnlogB with reading level and age were $r(33) = -0.05$ and $r(33) = -0.03$ respectively, while correlations of AnlogE with reading level and age were $r(33) = -0.14$ for both.

It can be concluded that children at both reading levels were making analogies between both the beginnings and ends of words, for both real words and nonsense words. These are important results. They show that the use of analogy does not increase with reading development, and is available very early in learning to read. However, children find analogies between the ends of words easier than analogies between the beginnings of words. This replicates the strong End effect found in Experiment 2, and suggests that there may be a close connection between analogies in reading and rhyme. Learning a clue word does not help much in reading other words which share common grapheme-phoneme correspondences, however, as little improvement in reading the Common Letter words was found, and as the improvement which did occur was only found in the Beginning condition. We now turn to the results of the non-readers (group 1).

The Results for the Non-Reading Group

The mean number of words read correctly by the non-readers is given in Table 7.6 (overpage). Pretest scores were always zero, and so only the scores on the experimental test sessions are presented. These have been added across words and nonsense words, as scores were roughly equivalent for both word types.

Most of the scores are zeroes, but where analogies can be made (for Analogous words in the Beginning and End conditions), some of the children did occasionally give the correct response. This seems to be true mainly of the End condition, where on average the children read one word correctly. As it was previously found that analogies between the ends of words were easiest, this result seems to be in line with the performance of the older children.

Table 7.6

Mean number of words and nonsense words read correctly by
wordtype for Group 1 out of 12

		<u>Wordtype</u>		
<u>Condition</u>	<u>Test</u>	<u>Analogous</u>	<u>Common Letter</u>	<u>Control</u>
Beginning	Anal.	0.11 (0.32)	0.00 (0.00)	0.00 (0.00)
End	Anal.	0.89 (1.37)	0.00 (0.00)	0.05 (0.24)
No Clue	Anal.	0.00 (0.00)	0.05 (0.24)	0.00 (0.00)

Note. Standard deviations in parentheses.

If analogies were being made, more Analogous words than Common Letter and Control words should be read correctly in the Beginning and End conditions, but not in the No Clue condition. To see whether the performance of the non-readers differed significantly from chance, a Friedman Two-way analysis of variance by ranks was carried out on each condition, comparing Analogous word scores to Common Letter and Control word scores. The Beginning and No Clue conditions showed no significant differences ($\chi^2(2, N = 18) = 0.25$ and 0.08 respectively). However, scores in the End condition did differ significantly ($\chi^2(2, N = 18) = 9.03, p < .001$). Post-hoc testing with the Wilcoxon matched pairs signed ranks test showed that the scores

- for the Analogous words were significantly different from the scores for the Common Letter and Control words in the End condition ($T = 0, N = 8, p < .01$, for both). It seems that even children who were not yet reading were capable of making analogies between the ends of words.

The results for the non-readers supported the pattern of

responding found for the non-readers in Experiment 2. More analogies were made between the ends of words than between the beginnings of words, where no evidence for analogy use was indicated. The demonstration that even children who were not yet reading could occasionally make analogies between the ends of words shows that analogy is a strategy which is used naturally by children when they begin to learn to read. This finding supports the position of Baron (1977), who has claimed that even kindergarteners can use analogies in reading.

The relationship between phonological awareness and analogy

It will be recalled that a number of tests of phonological awareness were given to the children following the experiment. The major question of interest here was whether a strong relationship would be found between analogy and rhyming. A specific relation between children's rhyming ability and their use of analogies to read new words might be expected, as discussed in the introduction to this chapter.

To show that there is a specific connection, one would have to establish that analogy is related to rhyming more than it is to other phonological skills. This prediction was tested by including two different measures of phonological skills in the study just described. These were the Bradley and Bryant oddity tests for rhyme and alliteration, and a test of phonological segmentation devised by Content, Morais, Alegria and Bertelson, (1982). There were two reasons for including the second task. One was to test the prediction that a child's ability to use analogies would have a weaker connection with this kind of segmentation than with rhyme. The other was to determine the importance of segmentation for analogy, as

analogies in reading require segmentation skills. A strong relationship between phoneme deletion performance and analogy might thus be expected. The correlations between these measures and performance on analogies between the beginnings (AnlogB) and ends (AnlogE) of words is given in Table 7.7.

Table 7.7

Correlations between Phonological Measures and Analogies

Groups 2 and 3

<u>Test</u>	<u>Bradley and Bryant</u>			<u>Deletion</u>	
	<u>Beg.</u>	<u>Mid.</u>	<u>End</u>	<u>Init.</u>	<u>Final</u>
AnlogB	0.38 [*]	0.38 [*]	0.32	0.17	0.42 [*]
AnlogE	0.43 [*]	0.20	0.38 [*]	0.17	0.50 ^{**}

Non-readers

AnlogE	0.21	-0.16	-0.09	-0.23	-0.15
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^{*}Significant at the 0.05 level.

^{**}Significant at the 0.01 level.

In order to see whether any of these significant relations would be maintained once the contribution of other factors such as memory had been partialled out, a multiple regression was first performed to examine the relationship between analogical ability and memory, verbal skills, age and reading age. The aim was to see whether any of these variables were significantly related to analogical ability, so that they could then be partialled out before the relationship between analogies and phonological awareness was examined. This was

done for groups 2 and 3 only, as there were no signs of any significant relationships between the phonological measures and analogy use for the non-readers.

Two multiple regressions were run, one taking analogies between the beginnings of words as the dependent variable (AnlogB) and one taking analogies between the ends of words as the dependent variable (AnlogE). Both looked at the effects of entering memory (digit span), verbal ability (BPVS), age and reading age into the equation together, and letting the programme choose which variables to enter first. The interactions between all these variables were also entered as a second step. The results are given in Table 7.8 (overpage).

Clearly, BPVS and Digit Span were significantly related to AnlogE, and BPVS and age were the variables which came closest to being significantly related to AnlogB. However, the (non-significant) interaction shown between BPVS and digit span for AnlogE suggests that the verbal skills component of the digit span test may be causing the significant relationship between AnlogE and memory.

A fixed order multiple regression was then run for AnlogB in which BPVS and age were entered as separate steps. The interaction between BPVS and age was entered as a third step. This showed that only BPVS was significantly related to AnlogB, whether BPVS was entered as the first step ($p < 0.01$) or as the second step ($p < 0.01$).

Table 7.8

Multiple regressions relating BPVS, Digit Span, Age and
Reading Age to analogy

	<u>Beta</u>	<u>T</u>	<u>P</u>
<u>DEPENDENT VARIABLE 1: ANLOGB</u>			

BPVS	0.88	1.19	0.24
Age	0.23	1.21	0.23
Reading Age	-0.03	-0.16	0.87
Digit Span	0.89	0.70	0.48

Step 2: Interactions			
BPVS x Digit Span	-0.85	-0.62	0.54
All other interactions: Minimum Tolerance Level reached.			

<u>DEPENDENT VARIABLE 2: ANLOGE</u>			

BPVS	0.61	4.22	0.0002
Age	0.23	1.43	0.16
Reading Age	-0.13	-0.91	0.37
Digit Span	0.31	2.04	0.05

Step 2: Interactions			
BPVS x Digit Span	-1.80	-1.53	0.14
All other interactions: Minimum Tolerance Level reached.			

A fixed order multiple regression was also run for AnlogE in which BPVS and DS were stepped out separately. The interaction between BPVS and DS was entered as a third step. This showed that only BPVS was significantly related to AnlogE, whether it was entered as the first step ($p < 0.001$) or as the second step ($p < 0.0001$). Verbal skills was therefore the only other independent variable included in the multiple regressions which looked at the relationship between analogy use and the different phonological measures.

In half the regressions examining the relationship between phonological awareness and analogies the dependent measure was of the number of analogies made between the beginnings of the clue and test words (AnlogB), and in the other half the dependent measure was of the number of analogies made between the ends of the clue and test words (AnlogE). There were three steps in each multiple regression, which always came in the same order. The first was a measure of the children's verbal skills (BPVS). The second was one of the two phonological measures, and the third was the interaction between the first two variables. The results are summarised in Tables 7.9 and 7.10 (overpage).

The tables show that the only variables to account for a significant amount of additional variance in these regressions were scores on the Bradley and Bryant tests of rhyme. The Content et al. measures of segmentation fell short of significance, and so did the Bryant and Bradley alliteration measure, which was expected to be related to analogies between the beginnings of words.

Table 7.9

<u>Three-step multiple regressions relating rhyming and phoneme deletion</u> <u>to analogy for AnlogB</u>				
	<u>Beta</u>	<u>R²</u> <u>Change</u>	<u>F</u>	<u>P.</u>
<u>DEPENDENT VARIABLE: ANLOGB</u>				

Step 1: BPVS	0.42	17.4	6.94	0.01
(Same for all)				

Step 2: B&B Beg.	0.28	7.5	3.20	0.08
B&B Mid.	0.40	15.2	7.19	0.01
B&B End	0.31	9.2	4.02	0.05
Phoneme Del.				
Initial	0.20	7.5	3.19	0.08
Final	0.36	8.9	3.87	0.06

Step 3: BPVS x Phonological Measure				
BPVS x B&B Beg.: Minimum Tolerance Level reached.				
BPVS x B&B Mid.	-0.83	0.8	0.35	0.56
BPVS x B&B End	-0.87	0.9	0.39	0.54
BPVS x Initial	-1.48	2.8	1.19	0.28
BPVS x Final: Minimum Tolerance Level reached.				

Table 7.10

Three-step multiple regressions relating rhyming and phoneme deletion
to analogy for AnlogE

	<u>Beta</u>	<u>R²</u>	<u>Change</u>	<u>F</u>	<u>P.</u>
<u>DEPENDENT VARIABLE: ANLOGE</u>					

Step 1: BPVS	0.55	30.7	14.65	0.001	
(Same for all)					

Step 2: B&B Beg.	0.26	6.7	3.45	0.07	
B&B Mid.	0.12	1.3	0.63	0.43	
B&B End	0.31	9.4	5.03	0.03	
Phoneme Del.					
Initial	0.24	5.7	2.85	0.10	
Final	0.31	6.4	3.28	0.08	

Step 3: BPVS x Phonological Measure					
BPVS x B&B Beg.: Minimum Tolerance Level reached.					
BPVS x B&B Mid.	-2.24	5.5	2.74	0.11	
BPVS x B&B End	-0.94	1.0	0.56	0.46	
BPVS x Initial	-1.05	1.4	0.70	0.41	
BPVS x Final: Minimum Tolerance Level reached.					

The significant results with rhyme provide convincing evidence for the hypothesis of a specific connection between rhyming and analogy. This supports the idea that rhyming ability predicts later reading skill partly because rhyming helps children to use strings of letters in the way required for analogies. Rhyming involves putting words into categories based on sound, which helps children to learn that there are sets of words which not only have sounds in common, but which share common orthographic sequences as well, and analogies naturally involve an appreciation of rhyme. The relationship between early rhyming skill and later reading development may thus be one mediated by analogical strategies for decoding print. The lack of a significant relationship between phoneme deletion and analogies suggests that segmentation skills do not play a critical role in the use of analogies in reading, although the strength of the relationship (which almost reached significance) suggests that segmentation is an important component of analogy.

Discussion

The demonstration that young children made analogies in reading when given clue words suggests that analogy may play an important role in reading development. Analogy cannot be the developmentally sophisticated strategy suggested by Marsh and Desberg (1983), as in the early stages of reading analogies are made irrespective of reading level, with even non-readers making some analogies between the ends of words. It is clear from the older children that when memory/content of the visual lexicon is controlled by keeping the clue word present, no developmental increase in analogy use is found.

The finding that analogies between the ends of words were easier than analogies between the beginnings of words suggests that

analogies in reading are closely related to rhyming skills. This was supported by the strong relationship found between performance on a rhyming test and the use of analogies between the ends of words. The End effect is also in accordance with the work of Treiman (1983, 1985), who has shown that the natural parsing units in words are the onset and rime (e.g. 'b' + 'eak'). However, a strong version of Treiman's theory would not predict analogies between the beginnings of words at all. The important finding that young children can and do use analogies between the beginnings of words in reading suggests that current notions of orthographic parsing must be extended.

The beginning and end effects are also relevant to current analogical theories of skilled reading. Glushko (1979) suggested that analogy may work either via the comparison of similar terminal vowel consonant segments between words, or via the "contribution of neighbours in all positions" (p. 684). He assumed that the former was most influential in determining pronunciation, citing "the salience of rhyme for adults, and the primacy with which this phonological judgement develops in children." (Glushko, 1981, p. 69). While analogies between the ends of words do seem to come first (shown by the non-readers), and are easier to make, the beginning effect shows that an analogy model based solely on terminal vowel consonant orthography is too simple. However, analogy does not depend on the number of shared letters between words either (orthographic neighbours in all positions), as little improvement was found for the Common Letter words. This suggests that lexical analogies depend on intact orthographic sequences at the beginnings and ends of words.

The finding that analogies are made in certain ways means that the results are also compatible with models of reading which

postulate large-unit rules (e.g. Patterson & Morton, 1985), or a combination of rules and analogy, analogies being used to apply rules (Baron, 1979). Such models differ in whether or not they postulate separate lexical and rule-based systems. If independence of the lexical and non-lexical systems is assumed, then the models cannot explain lexical effects in nonsense word pronunciation (see Chapter 5.3 - 5.4). If the specification of independence is relaxed, a clear distinction between analogy theories and rule-based theories cannot be made.

However, rule-based theories seldom specify how spelling-sound rules are extracted or compiled. An alternative possibility to Baron's suggestion that analogies are used to apply rules, and one also compatible with the results presented here, is that analogies are used to extract rules. For example, the kind of comparison involved in making a specific analogy like 'beak-peak' could help children to realise that words which rhyme tend to have the same spelling pattern at the end. This could then lead to the formation of general 'rules' such as '-eak' says "eak". The idea that analogies help in rule extraction would perhaps be a better characterisation of our results, as all the words used were new to the children, and so pre-stored rules were probably not available. By this account, using analogies would be helpful in acquiring the alphabetic principle.

Analogy is thus a useful strategy for reading single words, and seems to be available at all reading levels. No development in the ability to use analogy seems to occur when the basis for the analogy is provided. We can now ask whether analogies are used in spelling. To examine this question, the techniques of Experiment 2 were repeated on a smaller group of children with spelling.

CHAPTER EIGHTTHE USE OF ANALOGIES IN SPELLING

If children are able to make analogies between the spelling patterns in words in reading, it seems logical to propose that they should also be able to make analogies between words in spelling. Analogies in reading are based on a comparison between the spelling patterns in two words. If two words share a common spelling pattern, it can be predicted with some (although not complete) certainty that they will also share a common sound pattern. Thus it seems logical to propose that children might also use this spelling-sound knowledge to make predictions about the spelling patterns in words based on their common sounds. If two words sound similar (for example, if they rhyme) then it can be predicted, though not always correctly, that they will share a common spelling pattern. Children who can use analogies to read new words should therefore also be able to use analogies to spell new words.

Some of the evidence relating to spelling development in young children is compatible with the hypothesis that young children should use analogies to spell new words, and some of the evidence is not. Taking the positive side first, there is growing evidence that rhyming skill is a strong predictor of later spelling ability (Lundberg, Olofsson and Wall, 1980; Bradley and Bryant 1983, 1985). As analogy has been shown to be an important link in the chain connecting early rhyming ability and later reading ability, analogy may well play a very similar role in the connection between early rhyming ability and later spelling development. Rhyming may well underlie the use of analogies in spelling, and children who are

skilled at rhyming may also make more analogies in spelling than children who are poor at rhyming.

On the negative side, Marsh and his co-workers have presented some evidence which is intended to show that analogies are not used in spelling until the final stages of spelling development, and also that analogies in spelling appear much later than analogies in reading. This evidence was discussed in Chapter 3.2.ii. - 3.2.iii., and will be briefly recapped here.

Marsh, Freidman, Welch and Desberg (1980b) asked children to spell nonsense words like 'jation' which were analogues of real words like 'nation', and found that the youngest children (aged seven) could not use analogies in this task. Analogies in spelling were made by 0% of the seven year olds, 33% of the ten year olds, and 50% of the college students. However, as Marsh et al did not check that the younger children knew the real words necessary for the analogies, this developmental effect may be nothing to do with differences in analogical ability. Instead, it may simply reflect the fact that the younger children knew fewer of the real words from which analogies could be made.

This problem was not really overcome in a later study by Marsh, Friedman, Desberg and Saterdahl (1981). Here Marsh et al. presented the real word analogues to the children before giving them the nonsense words to try and spell. Again, ten year olds made significantly more analogies in spelling the nonsense words (49%) than did seven year olds (26%). However, the seven year olds could simply have been worse at recalling the spelling patterns of the real words at the time of spelling the nonsense words, and this could explain the developmental differences found. Furthermore, as Marsh et

al. do not present any data relating to the conditional probability of spelling a nonsense word correctly given knowledge of the real word analogue, the rationale for presenting the real words first is obscure.

Clearly, even though Marsh et al. concluded that young children were very poor at making analogies in spelling, such a conclusion is not necessitated by their results. Young children may be very good at making analogies between words in spelling if the basis for the analogy is known to them. This hypothesis is supported by an experiment by Henderson and Chard (1980), who found that if children were shown a word which they could not spell prior to being asked to spell it, then their subsequent attempts at spelling that word were better than if they were only shown the letters making up the word one at a time. Although this experiment did not involve analogies, it does suggest that some knowledge of a word's visual appearance will later help in spelling that word correctly. Hence if children can make predictions about the spelling patterns of words based on common sounds, knowledge of the spelling pattern of one word should help in spelling an analogous word correctly.

The question of whether children can use common sounds to make analogies between the spelling patterns in words was examined in Experiment 4. If children can make analogies in spelling, then giving them a basis for analogy by showing them a clue word should subsequently improve their spelling of words which sound similar to the clue word at either the beginning or the end. A child given a clue word like 'beak' should subsequently be able to spell analogous words like 'peak' and 'bean' correctly. The presence of a clue word should not improve the spelling of non-analogous words like 'bask',

however, unless learning a clue word also helps in spelling words which share some individual grapheme-phoneme correspondences with the clue word. While this was not the case in reading, it may be more likely in spelling, since spelling requires children to build up spelling patterns by generating graphemes for all the phonemes in a given word.

Experiment 4: The Use of Analogies in Spelling

Experiment 4 used a very similar method to that used in Experiments 2 and 3. Children played a wordgame in which they were asked to spell words both with and without a clue word to help them. Analogies could be made from the clue words to some of the test words. The same clue and test words were used as in Experiment 2, but only some of the word sets were used. A few minor changes to the procedure were also made. These are outlined below.

Method

Subjects

Children were again taken from the infant classes in a local primary school. Children from the reception class were not used as they had not yet learned to write all the letters in the alphabet. The spelling age of the children taking part was comparable to the Schonell reading age of the children in Experiments 2 and 3. The mean age of the group was 6;10 yr., range 5;11 - 7;5 yr., and the mean spelling age was 7;0 yr., range 6;1 - 8;2 yr. The children were also given the British Picture Vocabulary Scales as a measure of verbal

ability. The mean BPVS score was 103.7, s.d. 24.02³.

Procedure

The design used was very similar to that of Experiments 2 and 3. The children were seen three times, once for a Pretest and twice for Analogy sessions, given on separate days. A different condition was given in each Analogy session, but the procedure in each session was identical.

Pretest

In the Pretest, the children in the infant classes of the school being used (40 children) were given all the analogous and non-analogous words used in the experiment to spell. They were also asked to spell some other words which were not included in the experiment, so that the repetition of some of the spelling patterns was not evident. The words were presented both in isolation and in a sentence context by the experimenter (e.g. "Lake. I went sailing on the lake"). Children who could already spell most of the words being used were not included in the experiment. This left the 16 children who took part in the study.

Analogy sessions

In the Analogy sessions, the children were given a clue word which the experimenter read for them, such as 'beak', and were told that the clue word would help them in spelling some of the words which the experimenter was going to give them. No mention of how the clue word might help in spelling the test words was made. The

3

This figure is large because of two children who had very low scores. They were still included in the study because their spelling performance was in line with their chronological ages.

children were then asked to spell eight test words which were either analogous or non-analogous to the clue words. The words were presented both in isolation and in a sentence context exactly as in the Pretest. The order of presentation was determined by random number tables.

Conditions

In contrast to Experiments 2 and 3, there were only two conditions. These were Clue, in which a clue word was presented from which analogies could be made, and No Clue, in which no clue word was presented. Only two conditions were required as it was decided to present both the Beginning Analogous and the End Analogous words together in the same condition. If children can make analogies where they are appropriate, they should do this for words which are analogous to the clue words at either the beginnings or the ends, even if both types of words are given in the same condition.

Words

The same wordtypes as before were used, but since both Beginning and End Analogous words were given in the same condition, there were four different kinds of words. Two words of each type were presented for a given clue word. The wordtypes were respectively 1. Beginning Analogous words (bean), which could be spelled by making analogies from the beginnings of the clue words; 2. End Analogous words (peak), which could be spelled by making analogies from the ends of the clue words; 3. Common Letter words (bask), which had three letters in common with the clue words but which could not be spelled by analogy to the clue words, and 4. Control words (rain), which were the Analogous and Common Letter test words for a different clue word from

that which was being used in a given session. The rationale for using these wordtypes was identical to that in Experiments 2 and 3. The full list of words used is given in Table 8.1.

Table 8.1

Full list of words used - Experiment 4

<u>Clue</u>	<u>Beginning</u>	<u>End</u>	<u>Common Letter</u>
beak	bean bead	peak weak	lake bask
hark	harp harm	lark bark	hawk hair
rail	rain raid	tail hail	real lain
coat	coach coast	float boat	cast cost

To counterbalance the order of receiving the word sets and conditions, the children were split into two groups of eight matched for age and spelling age. The word sets were paired, so that the 'beak' and 'hark' words were always given together, as were the 'rail' and 'coat' words. Two clue words and their associated test words were given in each Analogy session. Each group received the words and conditions in different counterbalanced orders.

Post-tests

Following the experiment, the children were given the WISC digit span subtest and the Bradley and Bryant odd man out test of rhyming and alliteration, as in Experiment 3. These tests of phonological awareness were included to see whether analogies in spelling would be significantly related to rhyming skills in the same way as analogies in reading. The tests of phoneme deletion were not included, as both

had failed to be significantly related to analogy use in the reading experiment.

Predictions

If analogies are made between the sounds of words and used to predict the spelling patterns of new words, then more Beginning and End Analogous words should be spelled correctly at Analogy test than at Pretest in the Clue condition, where analogies can be made from the clue words, than in the No Clue condition, where no clue words are provided from which analogies can be made. If children can use the individual letter-sound correspondences in the clue words to help them in spelling words containing some of the same letter-sound correspondences, then a significant improvement in spelling the Common Letter words at Analogy test compared to Pretest should also be found in the Clue condition. Otherwise more Beginning and End Analogous words should be spelled correctly at Analogy test than Common Letter or Control words in the Clue condition, but not in the No Clue condition.

Results

The mean number of words spelled correctly in the Pretest and the Analogy test is given in Table 8.2 (overpage). The only improvement occurred on the Analogous test words in the Clue condition.

Table 8.2

Mean number of words spelled correctly in Experiment 4 out of 4

		<u>Wordtype</u>			
<u>Condition</u>	<u>Test</u>	<u>Beginning</u>	<u>End</u>	<u>CL</u>	<u>Control</u>
Clue	Pre.	1.00	0.94	0.75	1.06
		(1.21)	(1.18)	(1.00)	(1.24)
	Anal.	1.75	2.50	0.62	1.25
		(1.24)	(1.10)	(1.03)	(1.39)
No clue	Pre.	1.38	1.31	0.56	0.88
		(1.26)	(1.40)	(0.73)	(1.20)
	Anal.	1.25	1.50	0.63	0.94
		(1.44)	(1.21)	(0.96)	(1.29)

Note. Standard deviations in parentheses.

In order to check whether these results were significant, a 2 x 2 x 2 x 4 (Order groups x Condition (Clue and No Clue) x Test (Pretest and Analogy test) x Wordtype (Beginning Analogous, End Analogous, Common Letter and Control)) Anova was performed with repeated measures on Condition, Test and Wordtype. The dependent variable was the number of words spelled correctly. If analogies were being made in spelling, an interaction between Condition, Test and Wordtype would be predicted: more Beginning and End Analogous words should be spelled correctly at Analogy test in the Clue condition than in the No Clue condition. The number of Common Letter and Control test words spelled correctly at Analogy test should not improve in either condition. The Anova table is given in Table 8.3.

Table 8.3

Anova on the number of words spelled correctly in Experiment 4

	Sum of Sq.	d.f.	Mean Sq.	F	P.
1. Order (O)	9.38	1	9.38	0.66	n.s.
Error	198.84	14	14.20		
2. Condition(C)	2.07	1	2.07	5.79	0.05
C x O	0.00	1	0.00	0.01	n.s.
Error	4.99	14	0.36		
3. Test (T)	6.57	1	6.57	21.67	0.0005
T x O	0.00	1	0.00	0.01	n.s.
Error	4.24	14	0.30		
C x T	4.79	1	4.79	12.55	0.005
C x T x O	0.19	1	0.19	0.50	0.49
Error	5.34	14	0.38		
4. Wordtype(W)	30.79	3	10.26	25.73	0.0001
W x O	1.14	3	0.38	0.95	n.s.
Error	16.76	42	0.40		
C x W	0.70	3	0.23	0.16	n.s.
C x W x O	4.39	3	1.46	1.01	n.s.
Error	61.10	42	1.45		
T x W	7.51	3	2.50	5.47	0.01
T x W x O	0.70	3	0.23	0.51	n.s.
Error	19.23	42	0.46		
C x T x W	6.04	3	2.01	6.70	0.001
CxTxWxO	2.26	3	0.75	2.51	n.s.
Error	12.63	42	0.30		

The Anova showed a significant main effect of Condition ($F_{(1,14)} = 5.79, p < 0.05$). This was caused by more words being read correctly in the Clue condition than in the No Clue condition (1.23 vs. 1.05). There was also a significant main effect of Test ($F_{(1,14)} = 21.67, p < 0.0005$). This was due to more words being read correctly at Analogy test than at Pretest (1.30 vs. 0.98). The Anova also showed a significant main effect of Wordtype ($F_{(3,42)} = 25.73, p < 0.0001$). Tukey's tests showed that significantly more End Analogous and Beginning Analogous words were read correctly than Control words (1.56 and 1.34 vs. 1.03, p 's < 0.01 and 0.05 respectively).

Significantly more words of all types were read correctly compared to the Common Letter words (0.64, $p's < 0.01$).

The Anova produced a number of significant interactions, including an interaction between Condition, Test and Wordtype, which would be expected if analogies were being made. The two-way interactions will be discussed first.

The interaction between Condition and Test was significant ($F(1,14) = 12.55$, $p < 0.005$). Post-hoc tests (Newman-Keuls) showed that significantly more words were read correctly at Analogy test than at Pretest in the Clue condition (1.53 vs. 0.94, $p < 0.01$), but not in the No Clue condition (1.08 vs. 1.03). The number of words read correctly at Pretest did not differ significantly between the two conditions (Clue: 0.94, No Clue: 1.03). This shows that the children were only improving significantly at Analogy test in the Clue condition.

There was also a significant interaction between Test and Wordtype ($F(3,42) = 5.47$, $p < 0.01$). Post-hoc tests (Newman-Keuls) showed that this interaction was caused by performance on the End Analogous words. Significantly more End Analogous words were read correctly at Analogy test than at Pretest (2.00 vs. 1.13, $p < 0.01$), whereas performance on the other wordtypes did not differ significantly from Pretest to Analogy test (Beginning Analogous words: 1.19 to 1.50; Common Letter words 0.66 to 0.63; Control words 0.97 to 1.09). Hence the improvement from Pretest to Analogy test was greatest for the End Analogous words.

Finally, a significant interaction was found between Condition, Test and Wordtype ($F(3, 42) = 6.70$, $p < .001$). This shows that

analogies were being made. Post-hoc tests (Newman-Keuls) showed that the interaction was due to a significant improvement in spelling the Analogous words in the Clue condition only. In this condition, more Beginning Analogous words were spelled correctly at Analogy test than at Pretest ($p < 0.01$), and more End Analogous words were spelled correctly at Analogy test than at Pretest ($p < 0.01$). None of the other improvements from Pretest to Analogy test in either condition approached significance. This is exactly the result that would be predicted if children can use analogy to help in spelling new words. Clearly, the children were making analogies in spelling.

The post-hoc comparisons also showed a significant difference between Analogy test scores for the Beginning Analogous and End Analogous words, the End Analogous word scores being significantly greater than the Beginning Analogous word scores ($p < 0.05$). As in reading, children find analogies between the rimes in words easier than between the spelling patterns at the beginnings of words. This is an interesting result, as it suggests that an awareness of rhyme plays a role in analogies in spelling as well as in analogies in reading. This would fit the strong predictive relationship between rhyming skills and progress in spelling found by Lundberg et al. (1980) and by Bradley and Bryant (1983). If there is a connection between rhyming and analogies in spelling, this should be shown by a specific relationship between analogy use and the rhyming measures given in the post-tests. These will now be discussed.

The relationship between analogy and phonological awareness

The correlations between the number of analogies made between the beginnings (AnlogB) and the ends (AnlogE) of words and the measures of rhyme and alliteration were calculated. The results are

shown in Table 8.4. The digit span scores are included in the table, as memory seemed to play a bigger role in spelling than it did in reading, where the correlations with memory failed to reach significance (comparable correlations for reading were 0.03 and 0.19, respectively).

Table 8.4

Correlations between Phonological Awareness and Analogies

<u>Test</u>	<u>Bradley and Bryant</u>			<u>Digit Span</u>
	<u>Beg.</u>	<u>Mid.</u>	<u>End</u>	
AnlogB	0.45	-0.26	-0.09	0.26
AnlogE	0.43	0.19	0.52*	0.63**

*p< 0.05

**p< 0.01

As in Experiment 3, a number of preliminary multiple regressions were run to examine the contribution of variables such as spelling age, reading age and verbal ability to the use of analogies. Again, only BPVS was found to be important. A number of fixed order multiple regressions were then performed for both AnlogB and AnlogE, to look at the relationship between the Bradley and Bryant tests or digit span and analogies after controlling for verbal ability (BPVS). Three independent variables were entered into each equation in separate steps as before. The first step entered BPVS, the second step entered one of the Bradley and Bryant measures or digit span score, and the third step entered the interaction between BPVS and the second independent variable. The results are given in Tables 8.5 and 8.6.

As the tables show, there was a significant relationship between analogies between the ends of words and rhyming ($F = 4.51, p < 0.05$), and between analogies between the beginnings of words and alliteration ($F = 5.33, p < 0.04$). Memory was also strongly related to AnlogE ($F = 7.90, p < 0.01$).

Table 8.5

Three-step multiple regressions relating rhyming and digit span to analogy for AnlogB

	Beta	R^2 Change	F	P.
<u>DEPENDENT VARIABLE: ANLOGB</u>				

Step 1: BPVS	-0.29	8.2	1.25	0.28
(Same for all)				

Step 2: B&B Beg.	0.53	26.7	5.33	0.04
B&B Mid.	0.16	2.0	0.30	0.60
B&B End	0.03	0.0	0.00	0.93
Digit Span	0.38	13.2	2.18	0.16

Step 3: BPVS x Phonological Measure				
BPVS x B&B Beg.: Minimum Tolerance Level reached.				
BPVS x B&B Mid.	-0.83	0.8	0.35	0.56
BPVS x B&B End	-0.87	0.9	0.39	0.54
BPVS x Digit Span: Minimum Tolerance Level reached.				

Table 8.6

Three-step multiple regressions relating rhyming and digit span
 to analogy for AnlogE

	Beta	R^2 Change	F	P.
DEPENDENT VARIABLE: ANLOGE				
Step 1: BPVS	0.15	2.0	0.34	0.56
(Same for all)				
Step 2: B&B Beg.	0.42	16.7	2.68	0.13
B&B Mid.	0.16	1.9	0.25	0.62
B&B End	0.16	25.1	4.51	0.05
Digit Span	0.64	36.8	7.90	0.01
Step 3: BPVS x Phonological Measure				
BPVS x B&B Beg.: Minimum Tolerance Level reached.				
BPVS x B&B Mid.	-2.24	5.5	2.74	0.11
BPVS x B&B End	-0.94	1.0	0.56	0.46
BPVS x Digit Sp.: Minimum Tolerance Level reached.				

The pattern of relationships between analogies in spelling and measures of rhyming and alliteration is thus closer to our original hypothesis than the pattern of relationships found in reading. Our original hypothesis was that rhyming should be more strongly related to analogies between the ends of words, while alliteration should be

more strongly connected with analogies between the beginnings of words. Making analogies between the beginnings of words requires words which begin with the same spelling patterns to be categorised together, and these categories will often be the same as sound categories based on alliteration. Making analogies between the ends of words requires words which share similar spelling patterns at the end to be grouped together, and these categories will often be the same as sound categories based on rhyme. Thus analogies between the beginnings of words should be more strongly related to alliteration skills than to rhyming, and analogies between the ends of words should be more strongly related to rhyming skills than to alliteration.

These were the results found. Alliteration was significantly related to AnlogB, but analogies between the beginnings of words were not significantly related to the tests of rhyming. This supports the hypothesis that analogies between the beginnings of words require an appreciation of alliteration rather than of rhyme. Similarly, a significant relationship between analogies and rhyming was found for AnlogE (although with only one of the rhyming subtests), but analogies between the ends of words were not significantly related to alliteration. This suggests that rhyming is important for making analogies between the ends of words, while alliteration is not.

The strong relationship with memory found for AnlogE further suggests that in spelling, an awareness of similar sounds in words is not enough for the use of analogy. It is also important to be able to remember which orthographic sequence is related to a given sound pattern. Memory may thus play a larger role in making analogies in spelling than in reading.

Discussion

With respect to analogies, the results of Experiment 4 with spelling nicely mirror the results of Experiments 2 and 3 with reading. Children were able to use analogies to help them to spell new words. They could use the sound-spelling relationship of a known (clue) word to make inferences about the spelling patterns of similar-sounding words. As in reading, more analogies were made between the ends of words than between the beginnings of words. This may reflect the salience of rhyme for young children.

Having shown that young children can and do make analogies between the spelling patterns in words as they learn about written language, we can now ask whether analogies are used to a different extent in reading and in spelling. The number of possible spelling patterns which can be used to represent a given sound is far greater than the number of possible pronunciations which can be assigned to a given spelling pattern. Hence analogies may be used more frequently in reading than in spelling.

A second and related question is whether making analogies will always be helpful in reading and spelling development. Clearly, the inconsistency of spelling-sound relationships in English means that analogy will not always be a good strategy to use to decode new words. Analogies between words sharing similar spelling patterns can be misleading in reading (as words which are spelled in the same way are not always pronounced alike, for example 'bough', 'cough', 'rough', 'through'..), and also in spelling, as similar-sounding words are not always spelled in the same way (e.g. 'birch', 'church', 'perch', 'lurch'..). However, analogy may be less likely to mislead children in reading than in spelling, as a misleading analogy in

reading leads to a nonsense word (using 'beak' to read 'break' gives the nonsense word 'breek"), which provides a cue to the child that the analogy is inappropriate. In spelling there is no such cue.

As the use of an analogy strategy can be misleading, it is important to ask whether children use analogies differently when shown that spelling-sound patterns can be either consistent or inconsistent, and whether this behaviour differs between reading and spelling. These questions are examined in Chapter 9.

CHAPTER NINETHE EFFECT OF SPELLING-SOUND CONSISTENCY ON ANALOGIESIN READING AND SPELLING

It has been shown that young children can use analogies to read and spell new words, and do so much earlier developmentally than some authors have predicted. This finding raises the possibility that, rather than being a sophisticated strategy characteristic of skilled readers, analogy is a relatively primitive strategy most frequently used in the early stages of learning to read and spell.

One reason for thinking that analogy may be a strategy which is most characteristic of the beginning rather than the later stages of reading and spelling is that the use of analogy can lead a child to make errors. For example, if the only '-eak' words a child knows are words like 'steak', use of analogy to read a new word like 'weak' or to spell a new word like 'lake' will result in an error. Hence as children become aware of the inconsistencies of English orthography, they may rely less on analogies.

The experiments presented in this chapter set out to examine the conditions under which children do and do not make analogies in reading and spelling new words. One way to examine how children cope with the inconsistencies of English orthography is to ask whether children are more willing to make analogies on the basis of a word which they have just learned to read or to spell when shown that the spelling-sound correspondences in that word are consistent with those in another word than when shown that they are inconsistent with those in another word. If children are shown that spelling-sound patterns

are consistent across words (peak-leak), then they may feel that the use of an analogy strategy is safer than when they are shown that spelling-sound patterns can be inconsistent across words (peak-steak). When no information about the potential consistency or inconsistency of a spelling pattern is given (peak-loan), children may either choose to make analogies to new words as frequently as when they have information about consistency, or may limit their use of analogy until they have more information.

These questions were examined in Experiments 5 and 6. Experiment 5 looked at the question of ambiguity for analogies in reading, and Experiment 6 considered the same problem in spelling. The technique used was to teach children a pair of words which varied in consistency (e.g. peak-leak (consistent), peak-steak (inconsistent), peak-loan (unconnected)), and then to see how frequently analogies were made to new words such as 'beak', 'weak', 'break' (reading), and 'meek' (spelling). It was expected that children would make most analogies when taught about consistency, and fewest analogies (or no analogies) when taught about inconsistency. When given no information about consistency (peak-loan), it was expected that children would make fewer analogies than when taught about consistency, but more analogies than when taught about inconsistency. However, given that children made analogies in reading after learning a single new word (Experiments 2 and 3), this may not necessarily be the case. Children may make as many analogies when given no information about consistency as they do when shown that the spelling-sound pattern in one word is consistent with the spelling-sound pattern in another word.

Another aim of these experiments was to see whether analogies

would be made differently in reading and spelling. In reading, an inappropriate analogy (such as using 'peak' to read 'break') results in a nonsense word ("breek"), which gives the child a cue that the analogy is misleading. In spelling, no such feedback is possible, as there is nothing to tell the child that an error has been made. A child who uses 'peak' to spell a new word like 'meek' has no feedback cues to tell her that the choice of analogy is inappropriate. A spelling like 'meak' is perfectly acceptable phonologically, but is wrong orthographically, as the conventional spelling pattern has not been used. So in spelling, children have no way of deciding whether a given analogy is appropriate, whereas in reading they can use the production of nonsense words to help them. Therefore, children might be more prone to inappropriate analogies in spelling (using 'peak' to spell 'meek') than in reading (using 'peak' to read 'break'). Analogies may thus be used to a different extent in reading and in spelling in the case of such ambiguous words.

Finally, although the series of experiments completed so far has shown that analogy is a strategy which could well play an important role in the reading and spelling of new words, it could be argued that this finding is heavily dependent on the experimental technique used. The word game used in Experiments 2, 3, and 4 involved the continued presence of a 'clue' word from which analogies could be made. It could be claimed that this technique artificially promoted the use of analogy, since the only two words that the child saw on a given trial were the clue word (e.g. 'beak') and the test word (e.g. 'peak' or 'bean'). This juxtaposition of two very similar-looking words might have enhanced any tendency which children might have to use analogies in reading and spelling new words, or could even have encouraged them to use a strategy which they would not normally

employ.

One way to avoid this problem is to require the child to remember the words from which analogies can be made. This was the technique used in Experiments 5 and 6. Children were taught to read or to spell the words which could form the basis of an analogy, and these words were then removed from view. Analogies could only be made if the children used the spelling patterns of the words which they had learned during training at the time of seeing new analogous words. It was felt that this technique would more closely approximate normal reading and spelling.

Experiment 5: Spelling-Sound Consistency and Analogies in Reading

In Experiment 5, children were taught to read pairs of words with common spelling patterns which varied in the consistency of pronunciation of the rimes. This meant that they had to remember the words from which analogies could be made. Rimes were chosen because stronger effects for analogies between rimes were found in Experiments 2 and 3. Thus an effect of consistency on analogy use should show up most strongly in analogies between rimes.

Method

Subjects

24 children from the infant classes of a local primary school with a reading age of between six and seven years on the Schonell Graded Word Reading Test took part in the study. The children were also given the British Picture Vocabulary Scales. The mean age of the group was 7;3 yr., range 6;6 - 8;1 yr., the mean reading age was 6;9 yr., range 6;4 - 8;0 yr. As in Experiment 1, the school was in a

working class area, and many of the children were behind their chronological age in reading. Their relative delay was also shown by their BPVS scores. The mean BPVS score for the group was 92.3, s.d. 15.6 (average score for the population = 100).

Procedure

Every child was seen for three sessions. A different training condition was given in each session, and the three sessions were given on separate days. The procedure followed in each session was identical across conditions, and consisted of three parts, a Pretest, Training, and an Analogy test.

Pretest

In the Pretest, the training and test words to be used were presented one by one for the child to read. Each word was printed in lower case on a white card measuring 2" x 3", in black type 1/4" high. Seven words were given in each trial, and the order of presentation was determined by random number tables. The Pretest was designed to measure the children's initial knowledge of the words being used. The different words will be explained more fully below.

Training

Part 2 of each session consisted of a Training period, in which the child was taught to read a pair of words such as 'peak-leak'. The pair of words taught were either consistent in spelling and sound, consistent in spelling but inconsistent in sound, or unconnected in spelling and sound. This gave rise to three separate training conditions.

Conditions

The three training conditions were:

- I. Consistent, where the pair of words taught were consistent in spelling and sound (e.g. 'peak-leak');
- II. Inconsistent, where the pair of words taught were consistent in spelling and inconsistent in sound (e.g. 'peak-steak');
- III. Unconnected, where the pair of words taught were unconnected in spelling and sound (e.g. 'peak-loan').

Training Procedure

During training, the experimenter produced the words to be learned typed in lower case on a white card one above the other so that the orthographically consistent sequence was easily defined:

peak

leak

In all these conditions the child was then taught to read the pair of words by segmenting them into onset and rime. The experimenter first covered the onset of one word (e.g. the 'p' in 'peak'), and emphasised the rime by saying "These letters go together and they say 'eak'". The child then learned to read the rime of the word. Once this was recognised readily, the onset of the word was revealed and was sounded out for the child. The child was then helped to blend the two sounds together (e.g. 'p-eak says "peak"'). The criterion for learning was two successive correct responses. Once the word had been learned, the second word in the pair was learned in the same way.

If the rime of the second word was inconsistent with that of the first word or unconnected to it, it was simply taught in exactly the

same way. For example, for 'peak-steak', the experimenter said "These letters go together and they say 'ake'"; for 'peak-loan' the experimenter said "These letters go together and they say 'oan'". No comment on the inconsistency or otherwise of the pairs of words was made by the experimenter. In this way the child was left to notice the consistency or inconsistency of the words being taught for herself. Training usually lasted from three to five minutes.

Analogy Test

Part 3 of each session consisted of an Analogy test, identical to the Pretest. In the Analogy test, the children were given the training and test words to read singly as in the Pretest, the order of presentation again being determined on each trial by random number tables. The training pair was given again at Analogy test as a check that the words had been learned and so were available as a basis for making analogies. As all the children subsequently remembered the taught pair at Analogy test, this factor was not included in any of the later analyses.

Words

As well as the two trained words, five test words were given on each trial. These were of three types:

1. Analogous words (e.g. 'beak', 'weak'), which had the same spelling and sound as the taught pair, and so could be read correctly by the use of analogy.
2. Ambiguous words (e.g. 'break'), which shared the same spelling pattern as the taught pair but not the pronunciation. Using analogies to read the ambiguous words would lead to incorrect responses.
3. Control words (e.g. 'lion', 'tour'), which shared neither spelling

nor pronunciation with the taught pair, and so should not be read by analogy. The Control words were matched to the Analogous and Ambiguous words in CVVC pattern and frequency (using the Carroll, Davies and Richman (1971) norms). All the words used are given in Table 9.1.

Table 9.1
Full list of words used – Experiment 5

Taught Pairs			Test Words		
<u>Consis.</u>	<u>Incon.</u>	<u>Unconn.</u>	<u>Anal.</u>	<u>Ambig.</u>	<u>Control</u>
peak leak	peak steak	peak loan	beak weak	break	lion tour
good stood	good food	good seen	hood wood	mood	flee hair
own flown	own clown	own draft	sown mown	town	nook hang
rose nose	rose whose	rose shape	pose hose	lose	dent rage
boot toot	boot soot	boot lied	hoot root	foot	shear plain
seat neat	seat sweat	seat hook	beat meat	great	died teeth

In order to counterbalance the order of word sets and conditions, the children were split into three groups of eight matched for age and reading age. The word sets were grouped into three sets, which were always presented together. These sets were, respectively, the 'peak' and 'good' words, the 'own' and 'rose' words, and the 'boot' and 'seat' words. Children received these sets on separate days, each set being given in a different condition. This meant that each child was taught two word pairs per session. The order of receiving the conditions and the set of words given in each condition were varied in two 3 x 3 Latin squares. As only 24 children

took part in the experiment, the design was not fully balanced.

Predictions

It was expected that if analogies were being made, the number of words read correctly would improve on the Analogy test relative to the Pretest for the Analogous test words only. Most improvement was expected in the Consistent condition, where the orthographic sequence stressed had a consistent pronunciation across words, and least improvement (or no improvement) was expected in the Inconsistent condition, where the children were being reminded that spelling-sound relationships in English can be inconsistent. The improvement on the Analogous test words in the Unconnected condition was expected to fall somewhere in between the former and the latter.

In terms of the different wordtypes, it was expected that the number of Ambiguous and Control words read correctly would not improve significantly from Pretest to Analogy test. However, performance on the Ambiguous words was of special interest. If children were making analogies to the Ambiguous words in the Consistent or Unconnected conditions, this would lead to errors, as the only basis for making an analogy was inappropriate (e.g. using 'peak' or 'leak' to read 'break' would lead to a mispronunciation). However, in the Inconsistent condition the children were being given two models from which analogies could logically be made (e.g. 'peak' and 'steak'). Children in this condition could either choose to make analogies equally frequently from both these models, leading to possible errors on both the Analogous and Ambiguous words, or could choose to make analogies selectively, using 'peak' as a basis for reading 'beak' and 'weak', and 'steak' as a basis for reading 'break'. This would lead to better performance on the Ambiguous words

in the Inconsistent condition than in the other two conditions. So the behaviour of children in the Inconsistent condition should be especially informative about when children do and do not choose to use analogies to read new words.

Results

Two different analyses of the results were carried out. The first examined the number of words read correctly. This analysis was designed to see whether analogies were being used, and a big improvement in the number of Analogous test words read correctly was predicted.

However, if erroneous analogies were being made to the Ambiguous words, this would not be shown in this first analysis. The only indication of analogies to the Ambiguous words might be in the Inconsistent condition, where a selective use of analogy could lead to improvement in reading the Ambiguous words. A second analysis was thus conducted to see how frequently analogies were made on the Analogous and Ambiguous words, even where this led to errors. For this second analysis all responses which were analogous to the Consistent training pair were scored as correct, that is all responses which used the rime sound taught during the Consistent training condition were scored. If 'break' was read as "breek", it was counted on the second analysis but not on the first. A significant increase in the use of the taught sound for both the Analogous and the Ambiguous words was predicted.

Analysis 1: Number of words read correctly

The mean number of words read correctly by condition and wordtype is given in Table 9.2. The greatest improvement from Pretest

to Analogy test occurred for the Analogous test words, as predicted.

Table 9.2

Mean number of words read correctly in experiment 5 out of 4

<u>Condition</u>	<u>Test</u>	<u>Wordtype</u>		
		<u>Analogous</u>	<u>Ambiguous</u>	<u>Control</u>
Consistent	Pre.	1.08 (0.93)	0.92 (1.32)	1.04 (0.95)
	Anal.	3.38 (0.92)	0.83 (1.31)	1.25 (1.03)
Inconsistent	Pre.	0.92 (0.88)	1.17 (1.31)	1.04 (1.12)
	Anal.	2.21 (1.32)	1.58 (1.44)	1.29 (1.23)
Unconnected	Pre.	1.08 (1.14)	1.17 (1.17)	0.92 (1.10)
	Anal.	2.92 (1.21)	1.50 (1.47)	1.38 (1.10)

Note. Standard deviations in parentheses.

Improvement was tested by a 3 x 3 x 2 x 3 (Order group x Condition (Consistent, Inconsistent and Unconnected) x Test (Pretest vs. Analogy test) x Wordtype (Analogous, Ambiguous and Control)) Anova with repeated measures on Condition, Test and Wordtype, taking the number of words read correctly as the dependent variable. As it was usually only possible to find one example of an Ambiguous word for each spelling pattern, the Ambiguous word scores were doubled for the analysis. If analogies were being made, an interaction between Test and Wordtype should be found, as an improvement from Pretest to Analogy test would be expected for the Analogous words only. If analogies were being made to a different extent in the different conditions, an interaction between Condition, Test and Wordtype should be found, as the improvement in reading the Analogous words

from Pretest to Analogy test would vary with condition. The full Anova table is given in Table 9.3.

Table 9.3
Anova on the number of words read correctly in Experiment 5

	Sum of Sq.	d.f.	Mean Sq.	F	P.
1. Order (O)	5.85	2	2.92	0.39	n.s.
Error	156.33	21	7.44		
2. Condition(C)	1.14	2	0.57	0.31	n.s.
C x O	4.09	4	1.02	0.55	n.s.
Error	77.88	42	1.85		
3. Test (T)	65.33	1	65.33	191.44	0.0001
T x O	1.17	2	0.58	1.71	n.s.
Error	7.17	21	0.34		
C x T	0.93	2	0.47	0.88	n.s.
C x T x O	0.28	4	0.07	0.13	n.s.
Error	22.13	42	0.53		
4. Wordtype(W)	55.13	2	27.56	16.08	0.0001
W x O	4.98	4	1.25	0.73	n.s.
C x W	17.27	4	4.32	2.34	n.s.
C x W x O	11.16	8	1.39	0.76	n.s.
Error	154.79	84	1.84		
T x W	57.17	2	28.58	60.02	0.0001
T x W x O	1.83	4	0.46	0.96	n.s.
C x T x W	7.24	4	1.81	4.75	0.005
CxTxWxO	1.81	8	0.23	0.59	n.s.
Error	31.96	84	0.38		

The Anova showed a main effect of Test ($F(1,21) = 191.44, p < 0.0001$). This was due to more words being read correctly in the Analogy test than in the Pretest (1.81 vs. 1.04). There was also a main effect of Wordtype ($F(2,84) = 16.08, p < 0.0001$). Tukey's post-hoc tests showed that more Analogous words were read correctly than Ambiguous or Control words (1.93 vs. 1.19 and 1.15 respectively, $p's < 0.01$). The number of Ambiguous and Control words read correctly did not differ significantly.

The significant interaction between Test and Wordtype ($F(2,84)$

= 60.02, $p < 0.0001$) shows that analogies were being made. Post-hoc tests (Newman-Keuls) showed that the number of words read correctly at Analogy test was significantly greater than the number of words read correctly at Pretest for all the wordtypes (Analogous: $p < 0.01$; Ambiguous and Control: p 's < 0.05). However, the number of words of each type read correctly at Pretest did not differ significantly (Analogous: 1.03, Ambiguous: 1.08, Control: 1.00), whereas significantly more Analogous words than Ambiguous or Control words were read correctly at Analogy test (2.83 vs. 1.31 and 1.31, $p < 0.01$). This is exactly as predicted, and shows that the children were making analogies.

There was also a significant interaction between Condition, Test and Wordtype ($F(2,84) = 4.75$, $p < 0.005$). This suggests that the number of analogies made differed with training condition. Post-hoc tests (Newman-Keuls) showed that significantly more Analogous words were read correctly at Analogy test in the Consistent condition than in the Unconnected condition ($p < 0.01$), and in the Unconnected condition than in the Inconsistent condition ($p < 0.01$). This shows that most analogies were made in the Consistent (peak-leak) condition, where children were learning that similarity of spelling unambiguously predicts similarity of sound. Fewer analogies were made in the Unconnected condition (peak-loan), where the children were learning about the spelling-sound relations of two unconnected words. However, when inconsistent information was presented, as in the Inconsistent condition (peak-steak), even fewer analogies were made.

There are two possible explanations for the finding that fewest Analogous words were read correctly in the Inconsistent condition. One is that children in the Inconsistent condition may have made

analogies from both words in the taught pair, which may have led them to make inappropriate analogies to the Analogous words (e.g. using 'steak' to read 'beak'). This may have caused fewer Analogous words to be read correctly in this condition. The other is that teaching children about the inconsistency of letter-sound correspondences in English may have reduced their readiness to make analogies in reading. This could also have resulted in fewest analogies being made in the Inconsistent condition.

The first of these possibilities was examined by looking at the number of times that children made inappropriate analogies to the Analogous words in the Inconsistent condition. The inappropriate pronunciation (e.g. pronouncing 'beak' to rhyme with 'steak') was used 10 times out of a possible 96 at Analogy test, compared with 6 times at Pretest. In the Consistent condition, the inappropriate pronunciation was used 6 times at Pretest and 3 times at Analogy test, whereas in the Unconnected condition the inappropriate pronunciation was used 7 times at Pretest and once at Analogy test. Thus the inappropriate pronunciation was used slightly more frequently at Analogy test in the Inconsistent condition, but not strikingly so. This suggests that the second of these explanations - that children are less willing to make analogies when shown that the spelling-sound patterns in words can be inconsistent - is the correct one. It is important to note, however, that being taught about inconsistency does not prevent children from making any analogies to new words in reading. A significant number of analogies were still made to the Analogous words in the Inconsistent condition.

The question now is what happens to the Ambiguous words in the different conditions. Children in the Inconsistent condition may make

appropriate analogies to the Ambiguous words (e.g. using 'steak' to read 'break'), whereas in the Consistent and Unconnected conditions the only possible model for analogies to the Ambiguous words is an incorrect one. Thus the number of inappropriate analogies made to the Ambiguous words may vary with condition. These questions regarding the Ambiguous words are examined in the next section.

Analysis 2: Number of times the sound taught in the
Consistent condition was used

The second analysis concerned the number of analogies made, irrespective of whether the use of analogy led to correct or incorrect pronunciation of the test words. This was calculated by scoring the number of times that the Analogous and the Ambiguous words were read by analogy to the Consistent word pair (e.g. the number of times that the letter sequence '-eak' was read as in 'peak-leak'). Analogies to the consistent sound were possible in all the conditions (e.g. all the taught word pairs included 'peak').

This second analysis was designed to show how frequently children were making inappropriate analogies to the Ambiguous words. Inappropriate analogies should be made in the Consistent and in the Unconnected conditions, as the only model which the children can use as a basis for analogy will result in errors (e.g. 'peak' to read 'steak'). However, inappropriate analogies should be made less frequently in the Inconsistent condition, where the children were given an alternative model (e.g. 'steak') from which appropriate analogies to the Ambiguous words could be made. Children taught 'peak-steak' should be less likely to read 'break' as "breek" than children taught 'peak-leak' or 'peak-loan'.

The mean number of times the sound taught in the Consistent condition was used at Pretest and Analogy test is given in Table 9.4, separated by condition and wordtype. The figures for the Analogous words are not quite the same as in Table 9.2, as children would occasionally use the sound taught in the Consistent condition to read these words, but read them incorrectly (e.g. 'stone' for 'sown'). Figures for the Control words are not given as children never used the sound taught in the Consistent condition to read these words. This was expected, as the Control test words had different spelling patterns from the Analogous and Ambiguous test words, making the use of analogy completely inappropriate.

Table 9.4

Mean number of times taught sound used in Experiment 5 out of 4

<u>Condition</u>	<u>Test</u>	<u>Wordtype</u>	
		<u>Analogous</u>	<u>Ambiguous</u>
Consistent	Pre.	1.13 (0.90)	0.58 (0.93)
	Anal.	3.38 (0.92)	2.50 (1.59)
Inconsistent	Pre.	0.92 (0.88)	0.25 (0.68)
	Anal.	2.21 (1.32)	1.00 (1.32)
Unconnected	Pre.	1.17 (1.20)	0.33 (0.76)
	Anal.	2.92 (1.21)	1.75 (1.36)

Note. Standard deviations in parentheses.

The table shows that children made fewest inappropriate analogies to the Ambiguous words in the Inconsistent condition.

Performance was measured by a $3 \times 3 \times 2 \times 2$ (Order group $\times$ Condition (Consistent, Inconsistent and Unconnected) $\times$ Test (Pretest vs. Analogy test) $\times$ Wordtype (Analogous and Ambiguous)) Anova with repeated measures on Condition, Test and Wordtype. The number of times that the sound taught in the Consistent condition was used in reading was the dependent variable. Again, the Ambiguous word scores were doubled for the analysis.

If analogies were being made to both the Analogous and the Ambiguous words, a main effect of Test would be expected, as the use of the sound taught in the Consistent condition should increase from Pretest to Analogy test irrespective of wordtype. If the increase in the use of this taught sound differed for the Analogous and the Ambiguous words, for example because children used the sound taught in the Consistent condition more frequently to read the Analogous words than to read the Ambiguous words at Analogy test, an interaction between Test and Wordtype would be expected. This might occur because using the sound taught in the Consistent condition to read the Ambiguous words would result in nonsense words, providing children with a check on the appropriateness of the analogies. An interaction between Test and Wordtype would thus be evidence for the use of such a nonsense word check for preventing inappropriate analogies to the Ambiguous words.

If the number of analogies made to the Analogous and to the Ambiguous words differed with condition, an interaction between Condition and Test would be expected. For example, children may make more analogies in the Consistent and Unconnected conditions than in the Inconsistent condition. Finally, if analogies were being made to a different extent to the Analogous and the Ambiguous words, and if

this also differed with condition, an interaction between Condition, Test and Wordtype would be expected. This would occur if children made more inappropriate analogies to the Ambiguous words in the Consistent and Unconnected conditions only. The full Anova table is given in Table 9.5.

Table 9.5

Anova on the number of times the sound taught in the Consistent condition was used in Experiment 5

	Sum of Sq.	d.f.	Mean Sq.	F	P.
1. Order (O)	3.52	2	1.76	0.72	n.s.
Error	51.03	21	2.43		
2. Condition(C)	31.02	2	15.51	7.74	0.001
C x O	1.96	4	0.49	0.24	n.s.
Error	84.19	42	2.00		
3. Test (T)	175.78	1	175.78	146.98	0.0001
T x O	7.02	2	3.51	2.94	n.s.
Error	25.11	21	1.20		
C x T	13.56	2	6.78	6.97	0.005
C x T x O	1.42	4	0.35	0.36	n.s.
Error	40.85	42	0.97		
4. Wordtype(W)	56.00	1	56.00	30.79	0.0001
W x O	3.38	2	1.69	0.93	n.s.
Error	38.20	21	1.82		
C x W	1.13	2	0.57	0.47	n.s.
C x W x O	3.51	4	0.88	0.73	n.s.
Error	50.52	42	1.20		
T x W	2.92	1	2.92	4.50	0.05
T x W x O	1.38	2	0.69	1.07	n.s.
Error	13.61	21	0.65		
C x T x W	0.17	2	0.09	0.17	n.s.
CxTxWxO	0.81	4	0.20	0.41	n.s.
Error	20.85	42	0.50		

The Anova showed a main effect of Condition ($F(2,42) = 7.74$, $p < 0.01$). This was caused by the Consistent sound being used significantly more frequently in the Consistent condition than in the Inconsistent condition (1.90 vs. 1.09, $p < 0.01$, Tukey's). The

Unconnected condition did not differ significantly from either the Consistent (1.54 vs. 1.90) or the Inconsistent (1.54 vs. 1.09) conditions. There was also a main effect of Test ($F(1,21) = 146.98$, $p < 0.0001$). This was due to the sound taught in the Consistent condition being used more frequently at Analogy test than at Pretest (2.29 vs. 0.73). A main effect of Wordtype ($F(1,21) = 30.79$, $p < 0.0001$) was also found. This was caused by the sound taught in the Consistent condition being used more frequently to read the Analogous words than the Ambiguous words (1.95 vs. 1.07).

There were also some significant interactions. Taking the Test x Wordtype interaction first ($F(1,21) = 4.50$, $p < 0.05$), the pattern of results suggested that the interaction was due to the sound taught in the Consistent condition being used more frequently to read the Analogous words than the Ambiguous words at Analogy test than at Pretest. This pattern of results suggests that more appropriate analogies than inappropriate analogies were being made, which supports the idea that the children were using the creation of nonsense words as a check that a given analogy was appropriate.

However, it is impossible to be sure that this explanation of the interaction is the correct one, as post-hoc tests (Newman-Keuls) showed that all the possible differences were significant. The sound taught in the Consistent condition was used more frequently to read the Analogous than the Ambiguous words at both Pretest (1.07 vs. 0.39, $p < 0.01$) and Analogy test (2.83 vs. 1.75, $p < 0.01$), and the increase in the use of the taught sound from Pretest to Analogy test was significant for both the Analogous words (1.07 to 2.83) and the Ambiguous words (0.39 to 1.75) (p 's < 0.01). Thus while it is clear that the children were differentiating between the Analogous and the

Ambiguous words, the interaction between Test and Wordtype cannot be taken as unambiguous evidence for the use of a nonsense word checking mechanism to decide when use of the taught sound was appropriate. The children were obviously making a significant number of inappropriate analogies as well.

Turning now to the Condition x Test interaction ($F(2,42) = 6.97, p < 0.005$), post-hoc tests (Newman-Keuls) showed that the sound taught in the Consistent condition was used significantly more frequently at Analogy test in the Consistent condition than in the Unconnected condition (2.94 vs. 2.33, $p < 0.01$), and significantly more in the Unconnected condition than in the Inconsistent condition (2.33 vs. 1.60, $p < 0.01$), although Pretest differences were not significant (Consistent: 0.85; Inconsistent: 0.58; Unconnected: 0.75). The increase in the number of words read correctly from Pretest to Analogy test was significant for all conditions (p 's < 0.01). Thus the interaction was due to the sound taught in the Consistent condition being used most frequently at Analogy test in the Consistent condition, less frequently in the Unconnected condition, and least frequently in the Inconsistent condition.

This shows that the children made most analogies in the Consistent condition, where they learned that a spelling-sound relation was consistent across words. They made less use of analogy in the Unconnected condition, where no conflicting information concerning spelling-sound patterns was presented, and made least use of analogy in the Inconsistent condition, where the spelling-sound patterns were not consistent across words. Analogies were used less in the Inconsistent condition to read both the Analogous and the Ambiguous words, even though the Inconsistent condition offered two

models from which analogies could be made. However, a significant number of analogies were still made in the Inconsistent condition.

Children's behaviour in the Inconsistent condition will now be examined more closely. If the children were making selective use of analogy in this condition (e.g. using 'peak' to read 'beak' and 'weak', and 'steak' to read 'break'), the number of times that the sound taught in the Consistent condition was used to read the Ambiguous words should be less in this condition than in the other conditions. Children should also read more Ambiguous words correctly in this condition than in the other conditions.

Taking the number of inappropriate analogies made in the different conditions first, Table 9.4 shows some indication of a reduction in the number of inappropriate analogies made to the Ambiguous words in the Inconsistent condition. However, this reduction was not a significant one, as the interaction between Condition, Test and Wordtype was insignificant ($F(2,42) = 0.17$, n.s.). Inspection of the raw data showed that children read the Ambiguous words by analogy to the appropriate model (e.g. 'steak') 30 times out of a possible 96, and by analogy to the inappropriate model (e.g. 'peak') 24 times. Such inappropriate analogies to the Ambiguous words were made 54 times in the Consistent condition and 44 times in the Unconnected condition, nearly twice as frequently as in the Inconsistent condition (24 times). So some selective use of analogy was occurring in the Inconsistent condition, as the children were slightly more likely to use the appropriate model as a basis for analogies to the Ambiguous words. Nevertheless, this was a very small effect. (However, as one of the Inconsistent training pairs (seat-sweat) did not provide a model for the Ambiguous word (great),

children's ability to make analogies selectively may be underestimated).

Turning now to the number of Ambiguous words read correctly, Table 9.2 shows that the children did not read significantly more Ambiguous words correctly in the Inconsistent condition. This confirms that any selective use of analogy that was occurring did not have a major effect on performance. The inconsistency of the orthographic sequences obviously led to confusion, as fewest analogies were made in the Inconsistent condition, whether the measure used was the number of words read correctly or the number of analogies made. Clearly, teaching children about the inconsistency of English orthography limits their willingness to make analogies in reading.

Discussion

Experiment 5 has shown that children make more analogies in reading when shown that spelling-sound relations are consistent across words than when shown that spelling-sound relations are inconsistent across words, and can avoid some inappropriate analogies if given a choice of models. They can also avoid some inappropriate analogies by using the creation of nonsense words as a check on the appropriateness of a given analogy. This suggests that children are aware that analogy will not always be a useful strategy to use for reading new words, and can vary their application of it accordingly. The question now is whether children will show the same selective use of analogy in spelling.

There is reason to think that the use of analogies in spelling may differ from the use of analogies in reading. This is partly

because of the different processes involved in spelling and reading. One difference is that sound-to-spelling relationships are far more inconsistent than spelling-to-sound relationships (Hatfield and Patterson, 1983). Hatfield and Patterson state that "in general, there are far fewer phonological segments with predictable orthography than there are orthographic segments with consistent pronunciation" (p. 454). For example, an orthographic segment like '-aze' is always pronounced as in 'gaze', but the sound /ez/ can be represented as in 'gaze', 'ways', 'phase' and 'maize'. This difference between reading and spelling suggests that analogies may be far safer in reading than in spelling.

Another difference between reading and spelling has already been mentioned in the introduction to this chapter. This is that there are ways of checking whether an analogy is inappropriate in reading, but not in spelling. In reading, the use of an inappropriate analogy often results in a nonsense word, which gives a cue to the child that the analogy is misguided. In spelling, no such feedback is available. There may possibly be a way of deciding whether a given spelling pattern is the correct one by using a visual check that the word looks right. This means using reading knowledge to check candidate spellings. However, this is unlikely, as it has been suggested that young children do not combine their reading and spelling knowledge until fairly late in development (Bradley and Bryant, 1980), while bad spellers may never link their reading and spelling strategies (Frith, 1980).

The absence of a useful strategy for checking whether analogies are appropriate in spelling means that children should make inappropriate analogies in spelling as frequently as they make

appropriate analogies. This was examined in Experiment 6 by giving children both Analogous and Ambiguous words to spell. It was expected that in spelling as many analogies would be made to the Analogous words as to the Ambiguous words.

As well as the potential differences between analogies in reading and in spelling, some similarities between the use of analogy in reading and in spelling were expected. One similarity was that consistency should have an effect on children's willingness to use analogies to spell new words. Children who are taught about the inconsistency of spelling-sound relations in English should be less willing to use analogy to spell new words than children taught pairs of words which are consistent in spelling and sound.

In order to examine whether consistency affects analogies in spelling, and whether inappropriate analogies are made as frequently as appropriate analogies in spelling, Experiment 5 was repeated on a new group of subjects, with spelling rather than reading as the task under examination. Again, children were taught pairs of words which were either consistent in spelling and sound (e.g. speak-leak), consistent in spelling but inconsistent in sound (e.g. speak-steak), or unconnected in spelling and sound (e.g. speak-loan). Analogy was tested by giving children new words to spell which were either analogous to the words which they had learned ('beak', 'creak'), consistent in sound but inconsistent in spelling to the words which they had learned ('week', 'meek'), or unconnected ('tour', 'whisk').

Experiment 6: Spelling-Sound Consistency and Analogies in Spelling

Experiment 6 used exactly the same method as that used in Experiment 5 (Pretest, Training and Analogy test), the same

conditions, and almost the same training and test words. Children were again taught pairs of words which varied in the consistency of pronunciation of their rimes, but this time the children were taught to spell the words rather than to read them. Differences between the two experiments are outlined below.

Method

Subjects

27 children from the infant classes of a local primary school with a spelling age of around six and a half to seven years on the Schonell Graded Word Spelling test (1971) took part in the study. The British Picture Vocabulary Scales were again given as a measure of verbal ability. The mean age of the group was 6;8 yr., range 5;11 - 7;5 yr., the mean spelling age was 7;2 yr., range 6;6 - 7;10 yr. The mean BPVS score of the group was 109.6, s.d. 15.7.

Procedure

The design used for Experiment 6 was identical to that of Experiment 5. The children were seen for three separate sessions, in each of which they received a different training condition (Consistent, Inconsistent and Unconnected). The children were taught to spell the same pairs of words as in Experiment 5, and were tested both before and after training on their spelling of almost the same test words as were used previously. The test words used were of three types, Analogous, Ambiguous and Control, as in Experiment 5. The only changes made in the experimental procedure are outlined below.

i) Training

The child was again shown the pair of words to be learned

printed one above the other on a white card, so that the orthographically consistent sequences were aligned. The child was then taught to spell the words. This time training involved getting the child to write the words in the taught pairs for herself. The child first wrote only the letters making up the rime of the word being trained, so the child would write the '-e-a-k' part of 'speak' while the experimenter wrote the 'sp-' sound. Once the child could do this successfully without any visual feedback, the child was asked to write the whole word for herself. Previous attempts at spelling the word were always removed from view by the experimenter. Training continued until the taught pair could be written unaided twice in succession without reference to the visual prompt on the training card. Again, no reference to the consistency or otherwise of the words being learned was made by the experimenter. The training session usually lasted from five to ten minutes.

ii) Words

The Analogous and Control test words were the same as those used in the reading experiment. The Ambiguous test words were changed, however, so that instead of having the same orthographic sequence as the Analogous test words, they rhymed with them but were spelled differently. This was done because the Ambiguous test words in the reading experiment had been chosen to violate the principle that similarity of spelling predicts similarity of sound, and so it was felt that the Ambiguous test words in the spelling experiment should violate the principle that similarity of sound predicts similarity of spelling. Thus for Analogous test words like 'beak' and 'creak', the Ambiguous test words used were 'week' and 'meek'. Again, the words used were chosen to match the other test words as closely as possible

in word frequency, using the Carroll, Davies and Richman (1971) norms. All the words used are presented in Table 9.6. Spellings were always given in a sentence context to distinguish between homophones; however, most Ambiguous test words were not homophonic.

Table 9.6
Full list of words used - Experiment 6

<u>Taught Pairs</u>			<u>Test Words</u>		
<u>Consis.</u>	<u>Incon.</u>	<u>Unconn.</u>	<u>Anal.</u>	<u>Ambig.</u>	<u>Control</u>
speak leak	speak steak	speak loan	beak creak	week meek	tour whisk
cool pool	cool wool	cool leaf	tool fool	rule yule	beast fault
shown flown	shown clown	shown draft	blown thrown	bone cone	trick site
rose nose	rose whose	rose shape	chose hose	woes toes	breeze rage
boot toot	boot soot	boot lied	shoot root	lute cute	throat plain
seat neat	seat sweat	seat hook	beat meat	feet sheet	died teeth

In order to counterbalance the order of receiving the word sets and conditions, the children were split into three groups of nine matched for age and spelling age. The same method as used in Experiment 5 was then followed. The words were grouped into three sets ('speak' and 'pool' words, 'shown' and 'rose' words, and 'boot' and 'seat' words), and these sets were presented on different days in different training conditions. Each child thus received two word pairs per session. The order of receiving the conditions and the set of words given in each condition were varied in two 3 x 3 Latin squares.

Predictions

The predictions were very similar to those made in Experiment 5. It was expected that if analogies were being made, more Analogous words would be spelled correctly at Analogy test than at Pretest in all the conditions. Most improvement was expected in the Consistent condition, least in the Inconsistent condition, and intermediate improvement was expected in the Unconnected condition. The number of Ambiguous and Control test words spelled correctly was not expected to improve from Pretest to Analogy test. In contrast to the reading experiment, it was predicted that the Ambiguous words would be spelled by inappropriate analogies in all the conditions, as there is nothing to tell a child that the wrong analogy has been chosen in spelling. However, it was expected that fewer inappropriate analogies would occur in the Inconsistent condition than in the other conditions, as teaching children about the inconsistency of spelling-sound relations in English may make them more wary of using analogy for both the Analogous and the Ambiguous words in this condition.

Results

As in Experiment 5, the results were analysed in two different ways. The first analysis was based on the number of words spelled correctly. This analysis was designed to test whether analogies were being used. The second analysis was based on the number of times that the test words were spelled by analogy to the Consistent training pair. This was done by scoring the number of times that test words were spelled with the taught orthographic sequence, for example '-e-a-k', irrespective of whether this led to correct or incorrect spellings (so that 'c-r-e-a-k' for 'creak' and 'm-e-a-k' for 'meek'

were both scored). This second analysis was designed to see how often children made both appropriate and inappropriate analogies in spelling new words. Both these analyses are discussed more fully below.

Analysis 1: Number of words spelled correctly

The mean number of words spelled correctly by wordtype is given in Table 9.7. As in the reading experiment, the greatest improvement occurred for the Analogous test words in each case.

Table 9.7

Mean number of words spelled correctly in experiment 6 out of 4

<u>Condition</u>	<u>Test</u>	<u>Wordtype</u>		
		<u>Analogous</u>	<u>Ambiguous</u>	<u>Control</u>
Consistent	Pre.	1.19 (0.88)	1.15 (0.99)	0.52 (0.75)
	Anal.	2.55 (1.12)	0.89 (0.97)	0.48 (0.70)
Inconsistent	Pre.	0.96 (1.02)	0.93 (0.96)	0.44 (0.70)
	Anal.	2.22 (1.25)	0.85 (0.91)	0.37 (0.69)
Unconnected	Pre.	1.11 (1.09)	1.04 (0.85)	0.59 (0.75)
	Anal.	2.22 (1.25)	0.96 (0.98)	0.63 (0.63)

Note. Standard deviations in parentheses.

To analyse the results, a 3 x 3 x 2 x 3 (Order group x Condition (Consistent, Inconsistent and Unconnected) x Test (Pretest vs. Analogy test) x Wordtype (Analogous, Ambiguous and Control)) Anova was run with repeated measures on Condition, Test and Wordtype,

taking the number of words spelled correctly as the dependent variable. If analogies were being made, a significant interaction between Test and Wordtype would be expected, as more Analogous words should be spelled correctly at Analogy test than at Pretest, but no improvement on the other wordtypes should occur. If analogies were being made to a different extent in the different conditions, a significant interaction between Condition, Test and Wordtype would be expected, as the number of Analogous words spelled correctly at Analogy test compared to Pretest should differ between conditions. The full Anova table is given in Table 9.8.

Table 9.8

Anova on the number of words spelled correctly in Experiment 6

	Sum of Sq.	d.f.	Mean Sq.	F	P.
1. Order (O)	2.75	2	1.38	0.34	n.s.
Error	96.28	24	4.01		
2. Condition(C)	2.48	2	1.24	0.99	n.s.
Error	60.09	48	1.25		
3. Test (T)	15.93	1	15.93	38.96	0.0001
T x O	0.92	2	0.46	1.12	n.s.
Error	9.81	24	0.41		
C x T	0.00	2	0.00	0.01	n.s.
C x T x O	1.51	4	0.38	1.20	n.s.
Error	15.15	48	0.32		
4. Wordtype(W)	119.44	2	59.72	53.89	0.0001
W x O	8.14	4	2.03	1.84	n.s.
Error	53.20	48	1.11		
C x W	1.41	4	0.35	0.40	n.s.
C x W x O	5.94	8	0.74	0.85	n.s.
Error	83.54	96	0.87		
T x W	47.81	2	23.90	38.87	0.0001
T x W x O	3.01	4	0.75	1.22	n.s.
Error	29.52	48	0.61		
C x T x W	0.85	4	0.21	0.68	n.s.
CxTxWxO	4.74	8	0.59	1.91	n.s.
Error	29.74	96	0.31		

The Anova showed a main effect of Test ($F(1,24) = 38.69, p < 0.0001$). This was due to significantly more words being spelled correctly at Analogy test than at Pretest (1.24 vs. 0.88). There was also a main effect of Wordtype ($F(2,48) = 53.89, p < 0.0001$). Post-hoc tests (Tukey's) showed that significantly more Analogous words were spelled correctly than Ambiguous words (1.71 vs. 0.97, $p < 0.01$), and that significantly more Ambiguous words were spelled correctly than Control words (0.97 vs. 0.51, $p < 0.01$). This differs from the results of Experiment 5, where the number of Ambiguous and Control words read correctly was the same.

A significant interaction between Test and Wordtype ($F(2, 48) = 38.87, p < .0001$) was also found, which shows that analogies were being made. Post-hoc tests (Newman-Keuls) showed that the Analogous words were spelled significantly better at Analogy test than at Pretest (2.33 vs. 1.09, $p < 0.01$), while performance on the Ambiguous and Control words did not differ significantly from Pretest to Analogy test (Ambiguous: 1.04 and 0.90 respectively; Control: 0.52 and 0.49). The significant increase found in spelling the Analogous words correctly shows that the children were using analogies in spelling.

In contrast to the reading experiment, the Condition $\times$ Test $\times$ Wordtype interaction did not approach significance ($F(4,96) = 0.68$). This means that there were no differences in the number of analogies made in the different conditions. This finding is surprising, and suggests that analogies were made in spelling irrespective of the consistency of the taught pair, unlike in reading. Teaching children that spelling-sound relations can be inconsistent does not seem to affect their willingness to make analogies in spelling. This

difference in the results of the two experiments will be discussed more fully later.

In line with the reading experiment, a second analysis was performed to look at the use of analogy in spelling the Ambiguous test words. This analysis will now be discussed.

Analysis 2: Number of times the orthographic sequence taught
in the Consistent condition was used

The second analysis attempted to determine how frequently analogies were made, irrespective of whether or not the resulting spelling was an error. This was done by counting the number of times that the orthographic sequence taught in the Consistent condition (e.g. '-e-a-k') was used to spell the test words.

This second analysis was intended to show how frequently children were making inappropriate analogies to the Ambiguous words. As mentioned in the introduction to Experiment 6, there are no cues in spelling which a child can use to decide that an analogy is misguided. A child who decides to use a word like 'speak' to spell a similar sounding word like 'meek' cannot know that the analogy is inappropriate, unless her reading knowledge tells her that the spelling 'meak' does not 'look right'. However, it has been suggested that children use very different strategies in reading and spelling, without bringing the two strategies together until later in development (Bryant and Bradley, 1980). This hypothesis suggests that young children do not naturally use their reading knowledge to check their spelling attempts. Hence it was expected that inappropriate analogies would be made in spelling irrespective of condition, and that the orthographic sequence taught in the Consistent condition

would be used as frequently to spell the Ambiguous words as to spell the Analogous words.

The number of times that the orthographic sequence taught in the Consistent condition was used to spell the Analogous and the Ambiguous words at Pretest and Analogy test is given in Table 9.9 (overpage). Again, the figures for the Analogous test words differ slightly from those in Table 9.7, as children could spell words incorrectly even if they used the correct orthographic sequence. Common errors involved the omission of double consonants (e.g. 'bown' for 'blown', 'fown' for 'flown', 'soot' for 'shoot', 'cose/gose' for 'chose', and 'trown' for 'thrown'). Figures for the Control test words are not given. The children never used the orthographic sequence taught in the Consistent condition to spell these words, as would be expected since the Control words did not sound like the training pairs, and so there was no logical reason for spelling them by analogy to the training pairs.

The table shows that the orthographic sequence taught in the Consistent condition was used more frequently to spell the Analogous words than to spell the Ambiguous words, a result which was not predicted.

Table 9.9

Mean number of times the orthographic sequence taught in the
 Consistent condition was used in experiment 6 out of 4

Condition	Test	Wordtype	
		Analogous	Ambiguous
Consistent	Pre.	1.30 (0.99)	1.00 (0.78)
	Anal.	3.00 (1.00)	2.22 (1.19)
Inconsistent	Pre.	1.19 (1.14)	0.67 (0.73)
	Anal.	2.78 (1.34)	1.89 (1.37)
Unconnected	Pre.	1.15 (1.13)	0.59 (0.84)
	Anal.	2.56 (1.28)	1.67 (1.47)

Note. Standard deviations in parentheses.

To analyse the results, a 3 x 3 x 2 x 2(Order groups x Condition (Consistent, Inconsistent and Control) x Test (Pretest vs. Analogy test) x Wordtype (Analogous and Ambiguous)) Anova was performed with repeated measures on Condition, Test and Wordtype. Use of the orthographic sequence taught in the Consistent condition was the dependent variable. If children were making analogies to both wordtypes, a main effect of Test would be predicted, as the orthographic sequence taught in the Consistent condition should be used more frequently at Analogy test than at Pretest to spell both the Analogous and the Ambiguous words. If children were using the orthographic sequence taught in the Consistent condition to spell the Analogous words more than to spell the Ambiguous words, a main effect of Wordtype would be predicted. If children made more analogies to

the Analogous words than to the Ambiguous words, an interaction between Test and Wordtype would be predicted, as children should use the orthographic sequence taught in the Consistent condition to spell the Analogous words more than the Ambiguous words at Analogy test but not at Pretest. Finally, if children's use of analogy differed with the consistency of the pairs of words which they had been trained to spell, an interaction between Condition and Test would be predicted, as more Analogous and Ambiguous words should be read correctly in the Consistent condition than in the other conditions. The full Anova table is given in Table 9.10.

Table 9.10

Anova on the number of times the orthographic sequence taught in the Consistent condition was used in Experiment 6

	Sum of Sq.	d.f.	Mean Sq.	F	P.
1. Order (O)	1.56	2	0.78	0.19	n.s.
Error	98.78	24	4.12		
2. Condition(C)	8.39	2	4.19	2.23	n.s.
C x O	11.33	4	2.83	1.50	n.s.
Error	90.44	48	1.88		
3. Test (T)	152.11	1	152.11	54.01	0.0001
T x O	5.63	2	2.81	1.00	n.s.
Error	67.59	24	2.82		
C x T	0.72	2	0.36	0.38	n.s.
C x T x O	3.59	4	0.90	0.94	n.s.
Error	45.85	48	0.96		
4. Wordtype(W)	34.68	1	34.68	32.43	0.0001
W x O	0.32	2	0.16	0.15	n.s.
Error	25.67	24	1.07		
C x W	0.56	2	0.28	0.61	n.s.
C x W x O	6.27	4	1.57	3.42	0.05
Error	22.00	48	0.46		
T x W	3.16	1	3.16	9.89	0.005
T x W x O	0.17	2	0.09	0.27	n.s.
Error	7.67	24	0.32		
C x T x W	0.08	2	0.04	0.18	n.s.
CxTxWxO	0.75	4	0.19	0.85	n.s.
Error	10.67	48	0.22		

The Anova showed a main effect of Test ($F(1,24) = 54.01, p < 0.0001$), which shows that analogies were being made. This was caused by the orthographic sequence taught in the Consistent condition being used to spell more words at Analogy test than at Pretest (2.35 vs. 0.98). There was also a main effect of Wordtype ($F(1,24) = 32.43, p < 0.0001$). This was due to the orthographic sequence taught in the Consistent condition being used more frequently to spell the Analogous words than the Ambiguous words (1.99 vs. 1.34). This mirrors the results of Experiment 5.

A significant interaction between Test and Wordtype ($F(1, 24) = 9.89, p < .01$) was also found. The pattern of results suggested that the interaction was caused by the orthographic sequence taught in the Consistent condition being used more frequently to spell the Analogous words than the Ambiguous words at Analogy test than at Pretest. This suggests that the children were making more appropriate analogies to the Analogous words than inappropriate analogies to the Ambiguous words. This finding was not predicted, as it was argued that in spelling there is no way of checking whether the taught sequence is appropriate or inappropriate for spelling the different test words.

However, this interaction was difficult to interpret for exactly the same reason as in Experiment 5, which was that all the possible differences were significant. Post-hoc tests (Newman-Keuls) showed that the orthographic sequence taught in the Consistent condition was used significantly more frequently to spell the Analogous words than the Ambiguous words at both Pretest (1.21 vs. 0.75, $p < 0.01$) and Analogy test (2.78 vs. 1.93, $p < 0.01$), and that the use of the orthographic sequence taught in the Consistent condition increased

significantly from Pretest to Analogy test for both wordtypes (p 's < 0.01). While the latter result was predicted, the former was not. This pattern of results does not support the hypothesis that there is no cue in spelling to tell children when an analogy is inappropriate. There are two possible explanations of the interaction. One is that the children had some sub-threshold spelling knowledge which they used to decide whether the use of the taught orthographic sequence was appropriate for spelling the Ambiguous words. The other is that they used reading knowledge to decide whether a given analogy produced a spelling which 'looked right'. Further work is needed to decide which of these possibilities is the correct one.

The interaction between Condition, Wordtype and Order ($F(4,48) = 3.42$, $p < 0.05$) was not predicted. This interaction suggested that the orthographic sequence taught in the Consistent condition was used to spell the Analogous and Ambiguous words to a different extent in the different conditions depending on the order in which the conditions were received. Post-hoc tests (Newman-Keuls) showed that the interaction was caused by the children who received the Inconsistent condition first using the orthographic sequence taught in the Consistent condition as frequently to spell the Analogous words as the Ambiguous words in the Inconsistent condition (1.83 and 1.61 times respectively). Children in the other Order groups used the orthographic sequence taught in the Consistent condition significantly more frequently to spell the Analogous words than to spell the Ambiguous words in the Inconsistent condition (1.83 and 0.94 times for Consistent condition first ($p < 0.05$); 2.28 and 1.28 times for Unconnected condition first ($p < 0.01$)). This result shows that the children who received the Inconsistent condition before the Consistent condition were less sensitive to potential inconsistency

than children who received the Inconsistent condition after first receiving the Consistent condition.

The children in this Order group (Inconsistent condition first) also used the orthographic sequence taught in the Consistent condition to spell the Analogous words significantly more frequently than to spell the Ambiguous words in the Consistent condition, which they received last (2.11 vs. 1.11, $p < 0.01$). The children in the other Order groups used the orthographic sequence taught in the Consistent condition as frequently to spell the Analogous words as the Ambiguous words in the Consistent condition (2.39 vs. 2.17 for Consistent condition first; 1.94 vs. 1.56 for Unconnected condition first). This shows that children who received the Inconsistent condition first made fewer inappropriate analogies in the Consistent condition, perhaps because having already received the Inconsistent condition made them more sensitive to potential consistency and inconsistency. Both other Order groups received the Consistent condition before the Inconsistent condition. This interaction thus suggests that children are sensitive to consistency and inconsistency in spelling, but that the strength of this effect depends on the order of learning about consistent and inconsistent pairs of words. The consistency effect is much weaker than in the reading experiment.

The lack of a Condition x Test interaction ($F(2,48) = 0.38$, n.s.) shows that overall the children made analogies in spelling irrespective of condition. Again, this differs from the results of the reading experiment. It was predicted that children would make fewer appropriate and inappropriate analogies in the Inconsistent condition, as was the case in reading. Inspection of table 8.10 shows that this was not happening, as fewest analogies were actually made

in the Unconnected condition. Thus the small differences between the conditions in the number of analogies made were insignificant. The failure to find a reliable effect of consistency which was independent of order will be discussed more fully below.

Discussion of Experiments 5 and 6

Experiment 5 showed that in reading children made more analogies when the consistency of spelling-sound patterns in words was stressed, and fewer analogies when the inconsistency of spelling-sound patterns in English was brought to their attention. Furthermore, they avoided some inappropriate analogies in reading by checking whether an analogy resulted in a nonsense word, and to some extent made analogies selectively when given a choice of models for the analogy. Experiment 6 did not find completely similar effects in spelling, where no effect of spelling-sound consistency was found. This was surprising, as it had been predicted that children's spelling behaviour would be affected by the consistency of the pairs of words which they were taught to spell.

The differences between the reading and spelling experiments may be explained by the nature of the Inconsistent condition, which actually differed for the two experiments. In reading, where use of analogy depends on predicting sound from spelling, the Inconsistent word pair was truly inconsistent, since similarity of spelling did not predict similarity of sound. However, in spelling use of analogy depends on predicting spelling from sound, and so a comparable pair of inconsistent words should have been something like 'peak-seek', where similarity of sound does not predict similarity of spelling. This would have provided two models in the Inconsistent condition from which analogies to the Ambiguous words could have been made, as

in reading. Since the Inconsistent word pairs in the spelling experiment were inconsistent in spelling-sound relations ('peak-steak') rather than in sound-spelling relations (e.g. 'speak-seek'), this was not the case. Thus one way of making the two experiments more comparable would have been to include pairs like 'peak-seek' and 'shown-stone' in the Inconsistent training condition.

This difference in the kind of inconsistency used in the two experiments could also have been avoided by using different Ambiguous test words in the spelling experiment. If the children in the Inconsistent condition had been asked to spell test words which reflected the inconsistency between spelling and sound shown in the taught pairs used in Experiment 6, then the two experiments would also have been more comparable. The spelling experiment could have asked children to spell Ambiguous test words like 'bake' and 'lake', to test whether the children would use the '-e-a-k' sequence to represent the '-ake' sound after learning 'steak'. This would also have tested whether children could use analogy selectively in spelling (i.e. using 'steak' to spell 'lake').

Another surprising result was that both Experiments 5 and 6 found that more analogies were made to the Analogous words than to the Ambiguous words. While this result was predicted in reading, it was not predicted in spelling, where it was argued that children have no way of checking whether an analogy is inappropriate. The spelling result apparently showed that children did have some knowledge that the orthographic sequence taught in the Consistent condition was less appropriate for spelling the Ambiguous words. This may have been spelling knowledge, as the children already used this orthographic sequence less in spelling the Ambiguous words at Pretest. However,

another possible explanation for this finding is that the children were using reading knowledge to prevent some inappropriate analogies in spelling.

This leads to the question of whether reading knowledge can be shown to influence the analogies children make in spelling. Experiments 5 and 6 examined the use of analogy in reading and in spelling separately. However, in the real world the child is learning about both these processes at once. It was thus decided to examine whether there are any links between the use of analogies in reading and their use in spelling. This was done in Experiment 7, by combining the methodology of Experiments 5 and 6. Children were taught to read pairs of words, and then the effect on their spelling of new analogous words was assessed. The question of ambiguity was again examined at the same time.

The aim of Experiment 7 was thus to see whether children would make analogies from reading to spelling, and whether they would do so more often if they were taught pairs of words which were consistent in spelling and sound than if they were taught pairs of words which were inconsistent in spelling and sound. This experiment is presented in Chapter 10.

CHAPTER TENTHE EFFECT OF READING KNOWLEDGE ON ANALOGIES IN SPELLING

When children learn to read and spell, they normally learn about the two skills concurrently. This raises the question of how the development of the two skills is linked. Experiments 5 and 6 have shown that young children can use an analogy strategy to help in reading and spelling new words when they are taught about reading and spelling separately, and can modify their use of this strategy in reading when spelling-sound consistency is varied. The question to be examined in this chapter is whether they can use information gained in reading to make analogies in spelling, and if so whether spelling-sound consistency has an effect.

If reading knowledge can be used in spelling, then teaching a child to read a word such as 'peak' should have an effect on her spelling of new analogous words such as 'beak' and 'weak'. However, such links between reading knowledge and spelling behaviour would not be predicted by the strong form of the dissociation hypothesis put forward by Bryant and Bradley (1980), which was that young children use different and separate strategies for reading and for spelling.

Bryant and Bradley suggested that young children's reading depends on a visual strategy (recognising words by visual features), and spelling on a phonological strategy, where spellings are built up letter-by-letter through the application of individual letter-sound correspondences. The visual and phonological strategies were held to be used exclusively for reading and for spelling respectively. This hypothesis was based on the finding that children can both spell

words which they cannot read, and read words which they cannot spell. Bryant and Bradley argued that this double dissociation suggested that reading and spelling knowledge was independent.

Their examination of the categories of words either read but not spelled ($R\bar{S}$) or spelled but not read ($\bar{R}S$) suggested that these words differed qualitatively. The words which children could $R\bar{S}$ were words like 'school' and 'people', words which must be recognised visually, as the application of spelling-sound correspondences does not provide children with a correct pronunciation for these words. In contrast, the words which children could $\bar{R}S$ were words which were very regular phonologically, such as 'cut' and 'bun'. Such words can be correctly spelled by the use of individual grapheme-phoneme correspondences. From this, Bryant and Bradley argued that children were using separate and different strategies in reading and in spelling respectively. Children were using a visual strategy for reading and a phonological strategy for spelling.

Bryant and Bradley (1980) went on to show that children did not spontaneously use their phonological knowledge (spelling) in reading. They gave children the words which they had previously spelled but not read (e.g. 'cut') to read a second time, but this time buried in a list of nonsense words such as 'wef' and 'bip' (which can only be read phonologically). The children were then able to read the previously $R\bar{S}$ words perfectly well. From this, Bryant and Bradley argued that the children could use a phonological strategy in reading when encouraged to do so. However, left to themselves, young children preferred to use a visual strategy for reading, and reserved the phonological strategy (which they had available) exclusively for spelling.

Childrens' misspellings also suggest that they do not spontaneously use their visual knowledge in spelling. Children can read words that they cannot spell, which suggests that reading knowledge of a word's visual appearance is not enough for producing a correct spelling of that word. Bryant and Bradley argued that children did not bring their visual and phonological strategies together until later in development, when reading was at around the ten year level. It is only at this level that the category of words which can be spelled but not read disappears.

Clearly, the idea that seven year old children may use information gained through reading to modify their spelling of unknown words is incompatible with the strong form of Bryant and Bradley's hypothesis. If children use visual knowledge exclusively in reading and phonological knowledge exclusively in spelling, then they should be unable to use their reading knowledge to alter their spelling of unknown words. However, the use of analogies in reading and spelling involves a combination of both visual and phonological knowledge. Analogies in reading are based on a visual similarity between words being used to predict a phonological similarity, whereas analogies in spelling are based on a phonological similarity between words being used to predict an orthographic (visual) similarity. Thus children may be capable of using reading knowledge in spelling by making analogies from reading to spelling.

The main question to be examined in Experiment 7 is whether children can use information gained in reading to modify their spelling performance (i.e. whether children taught to read a word like 'peak' will modify their spelling of analogous words like 'beak'). This question was examined by using a combination of the

methods used in Experiments 5 and 6. Children were taught to read a pair of words which were either consistent in spelling and sound (peak-leak), consistent in spelling but inconsistent in sound (peak-steak), or unconnected in spelling and sound (peak-loan). Children's spelling of analogous ('beak', 'weak') and ambiguous ('meek', 'seek') words was then tested.

It was expected that children would use their knowledge of a word's spelling pattern gained through learning to read that word to modify their spelling of analogous words, and also of words that sounded analogous (the ambiguous words). As in Experiments 5 and 6, it was expected that most analogies would be made when the child learned that the spelling-sound relations in one word were consistent with those in another word. The number of analogies made when the child learned two words unconnected in spelling and sound was expected to be somewhat smaller. Fewest analogies were expected when the child was reminded that spelling-sound patterns in English can be inconsistent.

Experiment 7: Spelling-Sound Consistency in Reading and its Effect
on Analogies in Spelling

In Experiment 7, children were taught to read pairs of words with common spelling patterns which varied in the consistency of pronunciation of the rimes, exactly as in Experiment 5. Their spelling of Analogous, Ambiguous and Control words was then tested exactly as in Experiment 6. The method used was thus a combination of the methods used in Experiments 5 and 6, and the words used were a combination of those used in Experiments 5 and 6.

Method

Subjects

20 children took part in the study. They all came from a local primary school in a depressed area of Oxford, which meant that they were somewhat older than the children in Experiment 6, although their spelling ages were similar. The mean age of the group was 7;7 yr., range 6;10 - 8;5 yr. The mean Schonell reading age was 7;10 yr., range 6;10 - 9;0 yr., and the mean Schonell spelling age was 7;2 yr., range 6;2 - 7;11 yr. The children were also given the British Picture Vocabulary Scales as a measure of verbal ability. The mean BPVS score for the group was 96.0, s.d. 16.1.

Procedure

As in Experiments 5 and 6, each child was seen for three sessions, each session representing a different training condition. Each session consisted of three parts as before. These were: 1. a Pretest, in which the training and test words to be used were presented in random order for the child to spell both separately and in a sentence context (as in Experiment 6); 2. Training, in which the child was taught to read a pair of words such as 'peak-leak', the teaching procedure being conducted exactly as in Experiment 5; and 3. an Analogy test, identical to the Pretest, in which the training and test words were again presented in random order for the child to spell, as in Experiment 6. The training session was thus conducted exactly as in Experiment 5 (reading), while the Pretest and the Analogy test were conducted exactly as in Experiment 6 (spelling).

There were three types of test words, these being a combination of those used in Experiments 5 and 6. The Analogous and Control test

words were taken from Experiment 5, and the Ambiguous test words were taken from Experiment 6 (e.g. Analogous - 'beak', 'weak', Ambiguous - 'meek', 'seek' ('week' was changed to 'seek' to avoid confusion with 'weak'), and Control - 'lion', 'tour'). The full list of words used can be seen in Table 10.1.

Table 10.1
 Full list of words used - Experiment 7

Taught Pairs			Test Words		
<u>Consis.</u>	<u>Incon.</u>	<u>Unconn.</u>	<u>Anal.</u>	<u>Ambig.</u>	<u>Control</u>
peak leak	peak steak	peak loan	beak weak	seek meek	lion tour
good stood	good food	good seen	hood wood	could should	flee hair
own flown	own clown	own draft	sown mown	bone cone	nook hang
rose nose	rose whose	rose shape	pose hose	woes toes	dent rage
boot toot	boot soot	boot lied	hoot root	lute cute	throat plain
seat neat	seat sweat	seat hook	beat meat	feet sheet	died teeth

The three training conditions were identical to those used in Experiments 5 and 6, and were respectively Consistent (peak-leak), Inconsistent (peak-steak) and Unconnected (peak-loan). Training of the different word pairs proceeded exactly as in Experiment 5, with the children first learning to read the rimes of the training pair, and then learning to blend onset and rime together until both words had been learned to a criterion of two correct responses. Again, no explicit instruction as to the consistency or otherwise of the rimes was made by the experimenter. Furthermore, no mention of spelling was made during training.

In order to counterbalance the order of the word sets and conditions, the same procedure as previously was followed. The children were split into three groups (two groups of seven and one of six), matched for age and reading age. The word sets were grouped into three sets (the 'peak' and 'good' words, the 'own' and 'rose' words, and the 'boot' and 'seat' words), and each word set was given in a different condition on a separate day. The order of the conditions and the set of words given in each condition were varied in two 3 x 3 Latin squares. As there were only 20 children taking part in the study, the design was not fully balanced.

Predictions

If analogies were being made from the word pairs learned in reading, more Analogous words should be spelled correctly in the Analogy test than in the Pretest. No improvement in the number of Ambiguous or Control test words spelled correctly from Pretest to Analogy test would be expected. Furthermore, more analogies should be made to the Analogous words in the Consistent condition than in the Unconnected condition, and in the Unconnected condition than in the Inconsistent condition. This is because the children were being taught to read the training pairs rather than to spell them, and so teaching them about inconsistency in spelling-sound patterns should have the same effect as it did in the reading experiment (Experiment 5).

Two predictions are possible about the question of inappropriate analogies to the Ambiguous words. One is the prediction originally put forward in Experiment 6, which is that inappropriate analogies should be made to the Ambiguous words as frequently as appropriate analogies are made to the Analogous words, as there is no cue in

spelling to show children that a given analogy is misleading. The other possible prediction is that the result found in Experiment 6 may prove to be robust, with children making fewer analogies to the Ambiguous words than to the Analogous words. If this were to be the case, the same puzzling interaction between Test and Wordtype would be expected in the analysis of the number of analogies made.

Results

As in Experiments 5 and 6, two different analyses of the results were carried out. The first simply scored the number of words spelled correctly in the Pretest and in the Analogy test. If analogies were being made, a big improvement in the number of Analogous test words spelled correctly at Analogy test would be expected. The second analysis scored the number of times that the children used the orthographic sequence seen in the reading training sessions to spell the test words at Pretest and Analogy test. This analysis was designed to examine the number of analogies made from reading to spelling, irrespective of whether the use of analogy led to spelling errors. Children's use of analogy was scored by counting the number of times that they used the orthographic sequence learned in reading the Consistent training pairs to spell the Analogous and the Ambiguous words. Thus if 'meek' was spelled 'm-e-a-k', it was counted on the second analysis but not on the first. The two analyses were thus identical to those performed in Experiment 6.

Analysis 1: Number of words spelled correctly

If analogies are being made, more Analogous words should be spelled correctly in the Analogy test than in the Pretest, but the number of Ambiguous and Control words spelled correctly should not

improve. The mean number of words spelled correctly by wordtype is given in Table 10.2. As predicted, the greatest improvement seems to have occurred on the Analogous words.

Table 10.2

Mean number of words spelled correctly in Experiment 7 out of 4

<u>Condition</u>	<u>Test</u>	<u>Wordtype</u>		
		<u>Analogous</u>	<u>Ambiguous</u>	<u>Control</u>
Consistent	Pre.	1.25 (0.91)	1.20 (1.06)	0.80 (0.70)
	Anal.	2.25 (1.25)	0.70 (0.66)	0.80 (0.83)
Inconsistent	Pre.	1.40 (1.35)	1.20 (1.36)	0.75 (0.85)
	Anal.	2.35 (1.39)	1.15 (1.14)	0.80 (0.83)
Unconnected	Pre.	0.95 (1.10)	0.85 (0.93)	1.05 (1.28)
	Anal.	1.95 (1.05)	0.80 (0.83)	1.25 (0.91)

Note Standard deviations in parentheses.

Improvement was tested by a 3 x 3 x 2 x 3 (Order group x Condition (Consistent, Inconsistent and Control) x Test (Pretest vs. Analogy test) x Wordtype (Analogous, Ambiguous and Control)) Anova with repeated measures on Condition, Test and Wordtype. The number of words spelled correctly was the dependent variable. If analogies were being made, an interaction between Test and Wordtype would be predicted, as children should spell more Analogous words correctly at Analogy test than at Pretest, but no such improvement should occur in spelling the Ambiguous or Control words. If the number of analogies made to the Analogous words differed with spelling-sound consistency,

an interaction between Condition, Test and Wordtype would be predicted, as the number of Analogous words spelled correctly at Analogy test should vary with training condition. The full Anova table is given in Table 10.3.

Table 10.3

Anova on the number of words spelled correctly in Experiment 7

	Sum of Sq.	d.f.	Mean Sq.	F	P.
1. Order (O)	5.91	2	2.95	0.39	n.s.
Error	128.81	17	7.58		
2. Condition(C)	1.28	2	0.64	0.54	n.s.
C x O	4.84	4	1.21	1.03	n.s.
Error	39.95	34	1.18		
3. Test (T)	7.81	1	7.81	14.48	0.001
T x O	3.20	2	1.60	2.97	n.s.
Error	9.17	17	0.54		
C x T	0.66	2	0.33	1.24	n.s.
C x T x O	1.99	4	0.50	1.86	n.s.
Error	9.05	34	0.27		
4. Wordtype(W)	44.95	2	22.47	19.97	0.001
W x O	5.56	4	1.39	1.23	n.s.
Error	38.27	34	1.13		
C x W	7.87	4	1.97	1.59	n.s.
C x W x O	10.02	8	1.25	1.01	n.s.
Error	84.33	68	1.24		
5. T x W	22.90	2	11.45	43.30	0.001
T x W x O	0.55	4	0.14	0.52	n.s.
Error	8.99	34	0.26		
C x T x W	0.80	4	0.20	0.61	n.s.
CxTxWxO	2.70	8	0.34	1.03	n.s.
Error	22.34	68	0.33		

The Anova showed a significant main effect of Test ($F_{(1,17)} = 14.48$, $p < 0.001$). This was caused by more words being spelled correctly at Analogy test than at Pretest (1.34 vs. 1.05). There was also a significant main effect of Wordtype ($F_{(2,34)} = 19.97$, $p < 0.001$). Tukey's post-hoc tests showed that the Analogous words were

spelled correctly more often than the Ambiguous and the Control words (1.69 vs. 0.98 and 0.91, $p's < 0.01$). The Ambiguous and the Control words did not differ significantly.

A significant interaction was found between Test and Wordtype ($F(2,34) = 43.3$, $p < 0.001$). This showed that analogies were being made. Post-hoc tests (Newman-Keuls) showed that the Analogous test words were spelled significantly better at Analogy test than at Pretest (2.18 vs. 1.20, $p < 0.01$), while the Ambiguous and the Control test words were not (Ambiguous: 1.08 Pretest, 0.88 Analogy test; Control: 0.87 Pretest, 0.95 Analogy test). This shows that children were successfully making analogies from words learned in reading to similar-sounding words in spelling.

As in Experiment 6, the Condition x Test x Wordtype interaction did not approach significance ($F(4,68) = 0.61$, n.s.). This showed that there were no differences in the number of analogies made in the Consistent, Inconsistent and Unconnected conditions. The finding that there were no differences between conditions had not been predicted, because of the strong consistency effect found in Experiment 5, where the children were learning about inconsistency in spelling-sound relations in reading exactly as in the present experiment.

However, in the present experiment children's knowledge about inconsistency in reading was being tested through spelling, and so this could explain the different effects found in Experiments 5 and 7. The failure to find an effect of training condition suggests that in spelling, analogies are made irrespective of the consistency of the taught pair, even when children are taught to read rather than to spell the taught pair of words. The failure to find a consistency effect mirrors the results of Experiment 6, and will be discussed

more fully after the second analysis has been presented.

Analysis 2: Number of times the orthographic sequence seen in
reading the Consistent pair was used in spelling

In line with Experiments 5 and 6, a second analysis was performed to look at the use of analogy in spelling the Ambiguous test words. This was done by scoring the number of times that the Analogous and Ambiguous words were spelled with the Consistent orthographic sequence learned during the reading training, for example '-e-a-k', irrespective of whether this led to correct or to incorrect spellings (as in analysis 2 of Experiment 6).

This second analysis should indicate how frequently children were using inappropriate analogies from the taught pair to spell the Ambiguous words. There are two possibilities here. One is that inappropriate analogies will be made to the Ambiguous words in all the conditions, as there are no cues to the appropriateness or inappropriateness of an analogy in spelling. The other is that more appropriate analogies will be made to the Analogous words than inappropriate analogies to the Ambiguous words, as the children may have some way of deciding whether an analogy is appropriate in spelling. However, it was expected that fewer inappropriate analogies would be made in the Unconnected condition than in the Consistent condition, and fewest inappropriate analogies would be made in the Inconsistent condition. This was because learning about inconsistency should lead children to make fewest analogies overall in the Inconsistent condition, as was found in Experiment 5.

The mean number of times that the orthographic sequence seen in reading the Consistent word pair was used to spell the Analogous and

the Ambiguous words is given in Table 10.4. Figures for the Control test words are not given, as children never used the Consistent sequence to spell these words. This was as predicted, as the Control test words sounded very different from the words learned in the training pair, and so there was no reason to expect children to use analogies to spell these words.

Table 10.4

Mean number of times sequence seen in reading the Consistent word pair used in spelling in Experiment 7 out of 4

<u>Condition</u>	<u>Test</u>	<u>Wordtype</u>	
		<u>Analogous</u>	<u>Ambiguous</u>
Consistent	Pre.	1.20 (0.89)	0.75 (0.85)
	Anal.	2.20 (1.32)	1.90 (1.29)
Inconsistent	Pre.	1.40 (1.43)	0.75 (0.72)
	Anal.	2.25 (1.41)	1.35 (1.18)
Unconnected	Pre.	1.00 (1.12)	0.45 (0.76)
	Anal.	2.05 (1.19)	1.25 (1.21)

Note Standard deviations in parentheses.

To analyse the results, a 3 x 3 x 2 x 2(Order groups x Condition (Consistent, Inconsistent and Unconnected) x Test (Pretest vs. Analogy test) x Wordtype (Analogous and Ambiguous)) Anova was performed with repeated measures on Condition, Test and Wordtype, taking use of the orthographic sequence seen in reading the Consistent pair as the dependent variable.

If analogies were being made, a main effect of Test would be predicted, as the use of the Consistent orthographic sequence to spell both the Analogous and the Ambiguous words should increase from Pretest to Analogy test. If children were using the orthographic sequence seen in reading the Consistent word pair to spell the Analogous words more than to spell the Ambiguous words, there should be a main effect of Wordtype. If analogies were being used to a different extent to spell the Analogous and the Ambiguous words, there should be an interaction between Test and Wordtype, because the orthographic sequence seen in reading the Consistent word pair should be used more often to spell the Analogous words than the Ambiguous words at Analogy test than at Pretest. Finally, if there was an effect of the consistency of the taught pair on the number of analogies made, an interaction between Condition and Test would be expected, as the number of times that the orthographic sequence seen in reading the Consistent word pair was used in spelling both the Analogous and the Ambiguous words should vary with condition. The full Anova table is given in Table 10.5 (overpage).

The Anova showed a significant main effect of Test ($F(1,17) = 42.80, p < 0.001$). It was caused by the orthographic sequence seen in reading the Consistent word pair being used to spell more words at Analogy test than at Pretest (1.83 vs. 0.93). This shows that analogies were being made.

There was also a significant main effect of Wordtype ($F(1,17) = 10.94, p < 0.004$). This was due to the orthographic sequence seen in reading the Consistent word pair being used more frequently to spell the Analogous than the Ambiguous words (1.68 vs. 1.08). This result indicates that the children had some prior knowledge that the

orthographic sequence seen in reading the Consistent word pair was less appropriate for spelling the Ambiguous than the Analogous words, as found in Experiment 6.

Table 10.5

Anova on the number of times the seen sequence was used in
Experiment 7

	Sum of Sq.	d.f.	Mean Sq.	F	P.
1. Order (O)	2.89	2	1.45	0.33	n.s.
Error	74.36	17	4.37		
2. Condition(C)	4.88	2	2.44	1.03	n.s.
C x O	12.70	4	3.18	1.34	n.s.
Error	80.66	34	2.37		
3. Test (T)	49.29	1	49.29	42.80	0.001
T x O	0.00	2	0.00	0.00	n.s.
Error	19.58	17	1.15		
C x T	1.24	2	0.62	0.77	n.s.
C x T x O	5.90	4	1.48	1.82	n.s.
Error	27.54	34	0.81		
4. Wordtype(W)	21.81	1	21.81	10.94	0.01
W x O	1.33	2	0.67	0.33	n.s.
Error	33.88	17	1.99		
C x W	1.68	2	0.84	1.56	n.s.
C x W x O	0.25	4	0.06	0.11	n.s.
Error	18.35	34	0.54		
5. T x W	0.19	1	0.19	0.52	n.s.
T x W x O	0.24	2	0.12	0.32	n.s.
Error	6.31	17	0.37		
C x T x W	0.62	2	0.31	0.99	n.s.
CxTxWxO	1.73	4	0.43	1.37	n.s.
Error	10.73	34	0.32		

In contrast to Experiments 5 and 6, no significant interaction between Test and Wordtype was found ($F(1,17) = 0.52$, n.s.). This shows that the children were making as many analogies to the Analogous words as to the Ambiguous words. This supports the idea that in spelling there is no check which children can use to decide whether the use of the taught orthographic sequence is appropriate.

The children used the orthographic sequence seen in reading the Consistent word pair as frequently to make inappropriate analogies to the Ambiguous words as to make appropriate analogies to the Analogous words. This result will be discussed more fully later.

Finally, the failure to find an interaction between Condition and Test ($F(2,34) = 0.77$, n.s.) was contrary to predictions. It was expected that the children would make fewer analogies both to the Analogous and to the Ambiguous words in the Unconnected condition than in the Consistent condition, and fewest analogies of all in the Inconsistent condition, as was found in Experiment 5. However, this did not occur. The children in Experiment 7 used the orthographic sequence learned in reading to spell the test words to the same extent in all the conditions, even though they were learning that spelling-sound patterns can be inconsistent or unrelated in some of the conditions. The differences between the results of Experiments 5, 6 and 7 will now be discussed.

Discussion of Experiments 5, 6 and 7

Let us begin by considering how the main question examined in Experiment 7 has been answered. This was whether children could use knowledge gained through reading to modify their spelling behaviour. It was shown that previous studies (e.g. Bryant and Bradley, 1980) would not predict that reading knowledge should be used in spelling by seven year old children.

The most important finding of Experiment 7, therefore, was the demonstration that reading information is used in spelling new words. A child who has learned to read a new word will make analogies from that word to spell other new words which sound analogous to the word

that she has just learned to read. The use of information gained in reading to spell similar-sounding words would not be predicted by the strong form of Bryant and Bradley's (1980) dissociation hypothesis, which claimed that the strategies used in reading and spelling were independent of one another.

We turn now to a comparison of the results found in Experiments 5, 6 and 7. The major question in the three experiments was the effect of consistency on the use of analogies. Experiment 5 showed that children were more likely to make analogies in reading when shown that a pair of words was consistent in spelling and sound than when shown that a pair of words was unconnected or inconsistent in spelling and sound. Experiment 6 failed to find a similar effect of consistency in spelling. When children were taught to spell inconsistent pairs of words, they made analogies in spelling as frequently as when taught to spell consistent pairs of words.

The children in Experiment 7 were taught to read rather than to spell the pairs of words from which analogies could be made, and so it was expected that the same consistency effects would be found as in Experiment 5. However, when this reading knowledge was tested in spelling, no differences between learning consistent, inconsistent and unconnected word pairs was found. The results instead mirrored those of Experiment 6, where no effect of consistency was found. This shows that the crucial factor was whether the analogies were made in order to read or to spell new words. In spelling, children do not allow the consistency of spelling-sound relations to influence the analogies which they make, whereas in reading they do. This behaviour is quite logical given that there are many more orthographic representations of phonemes than there are phonemic representations

of graphemes (Hatfield and Patterson, 1983). Children's different use of consistency in reading and spelling may thus simply reflect the differences between reading and spelling. Consistency is much more usual in reading than in spelling, and so children use information about consistency in reading but not in spelling.

The results of Experiment 7 may also be partly explained by the nature of the Ambiguous test words, however. Since these all sounded analogous to only one of the taught words in the Inconsistent pair (e.g. 'meek' and 'seek' both sound like 'peak' in the pair 'peak-steak'), the inconsistent reading knowledge acquired by the children during training was only tested in one way in the spelling task. Children who learned that the letter sequence '-eak' could have more than one pronunciation were not asked to spell words which sounded similar to the inconsistent pronunciation which they had learned. This could have been achieved by asking the children to spell words like 'lake' and 'make' in addition to 'meek' and 'seek', so that they would have had to spell words which sounded like 'steak' but which were actually spelled differently. If such words were included in future experiments, an effect of inconsistency in spelling might be found.

The second question in the three experiments was whether analogy would be used in the same way in reading and in spelling. It was argued that the creation of nonsense words could be used to prevent inappropriate analogies in reading, but not in spelling. However, experiments 5 and 6 showed that the children were making more appropriate than inappropriate analogies in both reading and spelling. This result in spelling was difficult to explain.

Experiment 7 did not support the findings of Experiment 6 in

this respect. In Experiment 7, it was found that children made as many inappropriate analogies to the Ambiguous words as appropriate analogies to the Analogous words. This result supports the idea that there is no way of checking whether an analogy is appropriate in spelling. However, as the results of Experiment 7 and Experiment 6 were contradictory, it is difficult to make a firm conclusion. It is clear that the interaction found between Test and Wordtype in Experiment 6 is unreliable, but further work is needed to show whether children can decide that analogies in spelling are appropriate in some circumstances. In this respect it would have been helpful to collect data on whether the children could read the test words which they were asked to spell in Experiments 6 and 7. If children do use reading knowledge to decide whether an analogy in spelling 'looks right', then they should only make inappropriate analogies in spelling to words which they cannot read. This question remains to be examined.

Overall Discussion

The most important finding in Experiment 7 was that children made analogies from reading to spelling, a result which would not be predicted if children used different and independent strategies for reading and for spelling. This suggests that analogy is a strategy which can be both used separately in reading and in spelling, and can also be used to link knowledge acquired in reading to spelling. Analogy is a strategy which can unite reading and spelling knowledge, and so bridge the gap between the use of visual and phonological knowledge.

Experiments 5, 6 and 7 have further shown that not only can children use analogies to read and to spell new words, but that they

do so in different ways when the spelling-sound consistency of the pairs of words which they are taught as a basis for analogy is manipulated, and also do so differently depending on whether the task is one of reading or of spelling. In reading, children make more analogies when the spelling-sound relations in two words are consistent than when they are inconsistent or unconnected, but in spelling manipulating consistency in this way has no effect. When reading knowledge is tested in spelling, the consistency of the taught pairs again has no effect on the number of analogies made. As discussed above, the failure to find any effects of consistency on the use of analogies in spelling may have been partly due to the way in which knowledge about inconsistency was tested in the above experiments. However, it is clear that only some kinds of inconsistency are important in determining whether children will or will not decide to use analogies in spelling. Learning to spell words which are spelled consistently but pronounced inconsistently has no effect on making analogies in spelling.

Let us turn now to the question of task effects on performance. It was stated previously that Experiments 5, 6 and 7 were intended to provide a better test of children's spontaneous use of analogies in reading and spelling than Experiments 2, 3 and 4, which used a wordgame method and were open to the claim that the use of analogy was an artifact of the task being used. However, a criticism that might be made of the experiments presented in Chapters 9 and 10 is that the experimental situation was still not a good test of normal reading. Even though the children were required to remember the words from which analogies could be made in these experiments, the pairs of words which were taught were directly relevant to the task which preceded and followed the teaching.

Furthermore, all the experiments reported so far have presented single words to be read aloud (or spelled) in isolation. It could be argued that the experimental situations used are thus very different from normal reading, where the child has to decide how to pronounce new words in the course of reading text. The experimental situation is less different from normal spelling, where contextual cues do not usually play a role. However, it is clear that in reading, a case could be made for saying that analogy is not normally used to the extent suggested by experiments on the reading of single words. In order to look more closely at the use of analogy in reading, a further study was carried out. This examined whether analogies are used in normal prose reading. This study is presented in Chapter 11.

CHAPTER ELEVENTHE USE OF ANALOGIES IN PROSE READING

The experiments presented so far have shown that children can use analogies between the spelling patterns in words to read and to spell new words presented in isolation. We must now ask whether children use such analogies to decode new words which they encounter during the course of reading text. After all, the goal of learning to read is to be able to read stories and prose passages, and so any model of decoding has to be shown to be an effective strategy for reading text.

A frequent criticism of work which examines the decoding of single words in isolation is that the child is denied the help of context, which some authors have argued is crucial in helping children to decode new words (Smith, 1978; Goodman, 1982). However, recent work has shown that context plays only a minor role in individual differences in the decoding skills of young children (e.g. Stanovich and West, 1983; Stanovich, Cunningham and Feeman, 1984). These authors have shown that skilled and less-skilled readers at a comparable level of context-free decoding ability show the same degree of contextual facilitation when their speed and accuracy in reading stories is assessed. This shows that all children use context to help them in reading, and further shows that context cannot be a potent source of individual differences in reading ability. However, as the authors point out, if children of different context-free decoding levels are compared, the less efficient decoding skills of the poorer readers will result in these readers having less adequate contextual information available to help them. This means that

demonstrations that poorer readers make less use of context are confounded by the lower decoding level of the poorer readers. Even so, the idea that context plays a critical role in young children's reading is still very influential. It was thus decided to compare experimentally the role played by analogies and by context in reading prose.

To examine this question, a series of short stories was designed around the words previously used to assess children's use of analogy when taught clue words (Experiments 2 and 3). The stories were quite difficult to design, since it was important that the pronunciation of the analogous words was not given too obviously by the story context. If the identity of the analogous words had been unambiguously been given by the context, the child would have had no need to use other decoding skills such as analogy to help her, and so the use of analogies in reading prose would have been impossible to determine.

The rationale behind the experiment was as follows. If a child comes across some new words when reading a story, her performance on these words will partly demonstrate the effects of context on decoding skill. However, if the child comes across the same words in a story after first being taught to read an analogous 'clue' word, her performance will demonstrate the effects of both context and analogy on decoding skill. A comparison of children's performance on reading new words which are presented in stories when the child is either first taught an analogous (clue) word or receives no prior teaching can then demonstrate the effects of analogy on decoding skill independently of the effects of context.

Two conditions were thus used in the experiment. In one, the child was given the stories to read without first being taught to

read a related clue word from which analogies could be made. In the other, the child read the stories after first learning to read a clue word. The aim of this study was to find out whether, if a child learns a new word when reading a story, she will subsequently use her knowledge of this word to decode other similar new words encountered later in the story.

Experiment 8: Children's Use of Analogies in Reading Prose

In experiment 8, children were given short stories to read. Embedded in the stories were some of the matched analogical and non-analogical test words used in the previous studies. As far as possible, the test words were placed in positions in the passage where they could not be too easily worked out from the preceding context.

Method

Subjects

39 children from two local primary schools took part in the study. As in previous studies, the children were given the Schonell Graded Word Reading Test as a measure of reading level, and the British Picture Vocabulary Scales as a measure of verbal skills. The children were chosen so as to have reading ages comparable to the children who had taken part in previous studies. The mean age of the group was 7;0 yr., range 6;0 - 7;11 yr., the mean reading age was 6;10 yr., range 6;2 - 7;6 yr. The mean BPVS score of the group was 96.15, s.d. 11.47.

Procedure

The children were seen three times, once for a Pretest and twice for Analogy sessions, a different condition being given in each session.

Pretest

In the Pretest, all the children in the infant classes of the two schools (85 children) were given the test words to read, embedded in lists of other words suitable for seven year old reading levels. This provided information about whether the child could read the test words being used in the absence of context. Only children who could not already read many of the test words were included in the experiment. This resulted in 39 subjects being included.

Analogy Sessions

In the Analogy sessions, the children were given two stories to read. The stories were presented in little books which had the title of the story printed on the front cover. In order to introduce the teaching of the 'clue' words from which analogies could be made in a natural way, the clue words used in previous studies were part of the titles of the stories which the child was given to read (e.g. 'Hark! and listen'). The child was asked to read the title of the story with the experimenter before being allowed to see the story, and in this way was taught to read the clue word. Although the experimenter placed some emphasis on the child knowing the clue word, checking twice that the child could read the title of the story after the clue word had been learned, the child was not told that the clue word would later be important in reading the stories. Thus the child did not know that remembering the clue word would later help in reading

some of the new words in the stories by analogy.

Conditions

The first condition was the With Title condition. In this condition analogies could be made from a word in the title to analogous words buried in the stories. The second condition was the Without Title condition. In this condition no analogies could be made, as the child did not see the titles of the stories and so did not learn an analogous clue word from which analogies could be made. This design enabled the comparison of the effects of context alone on reading the test words (giving the stories without the titles), with the effects of being taught a clue word from which analogies could be made (teaching the clue word via helping the child to read the titles).

Story Types

The stories given were of two types, repeated clue and unrepeated clue. In the repeated clue stories, the clue word was repeated in the first line of each story as a check that the clue word had been learned from the title. This meant that for the repeated clue stories the clue word was seen twice in the With Title condition (in the title and again in the text), and once in the Without Title condition (in the text). In the unrepeated clue stories, the clue word was not repeated in the first line of the stories, in case seeing the clue word in the text affected the assumptions underlying the Without Title condition. This meant that for the unrepeated clue stories, the clue word was seen once in the With Title condition and was not seen in the Without Title condition. Repeating the clue word was not expected to have a strong effect,

however, as most children were unable to read the clue word correctly when it appeared in the first line of the repeated clue stories in the Without Title condition. This means that the assumptions underlying the Without Title condition should be unaffected.

Twenty-one children got the stories to read in books which repeated the clue word in the first line of the stories, and eighteen children got the stories to read in books which had the clue word on the cover only.

Words

There were three types of test words buried in the stories. These were exactly the same as the wordtypes used in Experiments 2, 3 and 4. The wordtypes used were respectively 1.Analogous Beginning, words which shared the same initial orthographic sequence as the clue words (e.g.HARK- harp, harm, hard); 2.Analogous End, words which shared the same final orthographic sequence as the clue words (e.g.HARK- dark, bark, lark); and 3.Common Letter, words which had three letters in common with the clue word but not in sequence (e.g.HARK- hear, hair, hawk). The Common Letter words were matched as closely as possible in frequency to the Analogous test words using the Carroll, Davies and Richman (1971) norms. Three words of each type were buried in each story. All the words used are given in Table 11.1 (overpage). The full text of the stories used is given in the Appendix.

It should be mentioned that the texts of the stories included some words which were very hard for the age group of the subjects. This was unavoidable, as the sets of clue and test words used made coherent stories quite hard to invent. Because of this, the child was

told beforehand that some of the words in the stories would be quite hard, and that the experimenter would help her to read any words which she did not know. If a child had particular difficulty with a given story, the experimenter read some of the words with the child so that the flow of the story was not broken too sharply during long pauses while the child tried to work out a difficult word. In this way, it was ensured that the adequacy of the contextual information was largely similar for all children.

Table 11.1
Full list of test words embedded in stories
in Experiment 8

<u>Clue</u>	<u>Beginning</u>	<u>End</u>	<u>Common Letter</u>
hark	harp	lark	hawk
	harm	bark	hair
	hard	dark	hear
rail	rain	tail	real
	raid	hail	lain
	raise	sail	pairs
seen	seed	queen	nest
	seem	green	nose
	seek	keen	send
coat	coach	float	cast
	coast	boat	cost
	coal	goat	cart

To counterbalance the order of receiving the different stories and conditions, the children were split into two groups (one of 20 and one of 19), matched for age and reading age. The stories were paired so that the 'hark' and 'rail', and the 'seen' and 'coat' stories were always given together. The pairs of stories were given in separate conditions on different days. The order of receiving the stories and conditions was counterbalanced. As there were 39 subjects, the design was not fully balanced.

Predictions

If context helps a child to decode new words in reading, some improvement in reading both the Analogous and the Common Letter test words should occur in the Without Title condition. If in addition analogies are being made from the words learned in the titles of the stories to the test words embedded in the texts, the improvement on the Analogous test words should be greater in the With Title condition than in the Without Title condition. Furthermore, if analogies are being made children should improve more on the Analogous test words than on the Common Letter test words in the stories in the With Title condition.

Results

Analysis 1: Number of words read correctly

The mean number of test words read correctly at Pretest and in the stories is given in Table 11.2 (overpage). As can be seen, the largest improvement is in the number of Analogous words read correctly in the With Title condition.

In order to see whether this pattern of results was significant, a $2 \times 2 \times 2 \times 2 \times 3$ (Order $\times$ Repeated Clue $\times$ Condition (With Title and Without Title) $\times$ Test (Pretest vs. Analogy Test) $\times$ Wordtype (Analogous Beginning, Analogous End, and Common Letter) Anova was carried out with repeated measures on Condition, Test and Wordtype. The number of words read correctly was the dependent variable.

Table 11.2

Mean number of words read correctly in experiment 8 out of 6

	<u>With Title</u>			<u>Without Title</u>		
	<u>Beg.</u>	<u>End</u>	<u>CL</u>	<u>Beg.</u>	<u>End</u>	<u>CL</u>
<u>Repeated Clue</u>						
Pretest	0.71	1.29	1.14	0.90	1.81	0.95
	(0.90)	(1.55)	(1.53)	(1.61)	(1.57)	(1.50)
Anal.	2.76	3.19	1.43	1.71	1.90	1.48
	(1.61)	(1.57)	(1.50)	(1.23)	(1.92)	(1.50)
<u>Unrepeated Clue</u>						
Pretest	0.94	1.72	0.78	1.22	1.39	0.78
	(1.16)	(1.60)	(1.22)	(1.06)	(1.46)	(0.81)
Anal.	2.56	3.56	1.89	1.83	2.17	1.50
	(1.72)	(1.65)	(1.37)	(1.25)	(1.62)	(1.10)

Note. Standard deviations in parentheses.

If context alone can explain any improvements found from Pretest to Analogy test, a main effect of Test would be predicted, without any interaction between Condition and Test. Such a pattern would indicate that the children were improving on all the wordtypes at Analogy test, because at Analogy test they had the story context to help them. However, an interaction between Condition and Test would indicate that the improvements from Pretest to Analogy test differed

depending on condition.

If analogies were being made to the Analogous words in the stories, an interaction between Condition, Test and Wordtype would be predicted, as the number of Analogous words read correctly at Analogy test should be greater than the number of Common Letter words read correctly at Analogy test for the With Title condition only. Finally, if repeating the clue word in the first line of the stories had an effect on analogy, an interaction between Condition, Test, Wordtype and Repeated Clue would be expected, as repeating the clue word should enable children to make analogies to the Analogous test words but not to the Common Letter test words in both the repeated clue stories in the With Title and the Without Title conditions and the unrepeated clue stories in the With Title condition. The full Anova table is given in Table 11.3 (overpage).

The Anova showed a significant main effect of Test ($F(1,35) = 93.32, p < 0.0001$), which was due to more words being read correctly at Analogy test than at Pretest (2.16 vs. 1.14). There was also a significant main effect of Wordtype ($F(2,70) = 22.64, p < 0.0001$). Post-hoc tests (Tukey's) showed that significantly more Analogous End words were read correctly than Analogous Beginning words (2.12 vs. 1.58, $p < 0.01$), and significantly more Analogous Beginning words were read correctly than Common Letter words (1.58 vs. 1.24, $p < 0.05$). There was no main effect of Repeated Clue ($F(1,35) = 0.09, n.s.$), which showed that repeating the clue word in the first line of the stories had no overall effect on the number of words read correctly. The main effect of Condition just missed significance ($F(1,35) = 3.69, p < 0.06$).

Table 11.3

Anova on the number of words read correctly in Experiment 8

	Sum of Sq.	d.f.	Mean Sq.	F	P.
1. Rep. Clue(RC)	0.96	1	0.96	0.09	n.s.
Order (O)	8.07	1	8.07	0.74	n.s.
RC x O	1.32	1	1.32	0.12	n.s.
Error	381.40	35	10.90		
2. Condition(C)	14.96	1	14.96	3.69	n.s.
C x RC	0.52	1	0.52	0.13	n.s.
C x O	0.00	1	0.00	0.00	n.s.
C x RC x O	0.18	1	0.18	0.04	n.s.
Error	142.00	35	4.06		
3. Test (T)	121.50	1	121.50	93.32	0.0001
T x RC	0.91	1	0.91	0.70	n.s.
T x O	1.62	1	1.62	1.24	n.s.
T x RC x O	1.15	1	1.15	0.88	n.s.
Error	45.57	35	1.30		
C x T	22.23	1	22.23	23.54	0.0001
C x T x RC	0.10	1	0.10	0.11	n.s.
C x T x O	0.37	1	0.37	0.39	n.s.
CxTxRCxO	0.63	1	0.63	0.67	n.s.
Error	33.05	35	0.94		
4. Wordtype(W)	61.83	2	30.92	22.64	0.0001
W x RC	0.64	2	0.32	0.24	n.s.
W x O	3.56	2	1.78	1.30	n.s.
W x RC x O	0.98	2	0.49	0.36	n.s.
Error	95.58	70	1.37		
C x W	4.54	2	2.27	1.51	n.s.
C x W x RC	2.41	2	1.20	0.80	n.s.
C x W x O	2.04	2	1.02	0.68	n.s.
CxWxRCxO	8.80	2	4.40	2.94	n.s.
Error	104.82	70	1.50		
T x W	8.26	2	4.13	7.19	0.001
T x W x RC	3.67	2	1.84	3.20	0.05
T x W x O	0.51	2	0.26	0.45	n.s.
TxWxRCxO	1.70	2	0.85	1.48	n.s.
Error	40.18	70	0.57		
C x T x W	9.72	2	4.86	9.27	0.0005
CxTxWxRC	2.32	2	1.16	2.22	n.s.
CxTxWxO	0.40	2	0.20	0.38	n.s.
CxTxWxRCxO	1.54	2	0.77	1.47	n.s.
Error	36.71	70	0.52		

A number of significant interactions was found, including an interaction between Condition, Test and Wordtype, as would be expected if analogies were being made. The two-way interactions will be discussed first. The interaction between Condition and Test was significant ($F(1,35) = 23.54, p < 0.0001$). Post-hoc tests (Newman-Keuls) showed that significantly more words were read correctly at Analogy test than at Pretest in both the With Title condition (2.56 vs. 1.09, $p < 0.01$) and the Without Title condition (1.76 vs. 1.18, $p < 0.01$). This shows that the children were improving in both conditions, which was probably due to the effects of context. However, the number of words read correctly in the two conditions did not differ significantly at Pretest, but did differ significantly at Analogy test, more words being read correctly in the With Title condition (2.56 vs. 1.76, $p < 0.01$). This shows that significantly more words were read correctly at Analogy test in the With Title condition, suggesting that analogies to the clue words were having a separate and significant effect on the improvements found in reading.

The interaction between Test and Wordtype was also significant ($F(2,70) = 7.19, p < 0.001$). Post-hoc tests (Newman-Keuls) showed that more words of all three types were read correctly at Analogy test compared to Pretest (p 's < 0.01). However, significantly more Analogous End words than Analogous Beginning or Common Letter words were read correctly at Pretest (1.55 vs. 0.94 and 0.92, p 's < 0.01), whereas at Analogy test significantly more Analogous End words were read correctly than Analogous Beginning words (2.69 vs. 2.22, $p < 0.01$), and significantly more Analogous Beginning words were read correctly than Common Letter words (2.22 vs. 1.56, $p < 0.01$). This suggests that the children were better at reading the Analogous End words even before they could use analogies to help them. Once the use

of analogy was possible, analogies were made to both kinds of Analogous words, and so these words were read significantly better than the Common Letter words at Analogy test. However, the finding that the Analogous End words were already read better at Pretest complicates the interpretation that analogies were being made to both wordtypes.

A significant interaction was also found between Test, Wordtype and Repeated Clue ($F(2,70) = 3.20, p < 0.05$); this was not predicted. The interaction suggests that repeating the clue words in the first line of the stories caused some wordtypes to be read better than others at Analogy test. However, post-hoc testing (Newman-Keuls) showed that the interaction was largely due to differences in performance on the Common Letter words. The children receiving the unrepeated clue stories improved significantly on the Common Letter words compared to Pretest (from 0.78 to 1.69, $p < 0.01$), while the children receiving the repeated clue stories did not (1.05 to 1.45). However, this improvement does not pose problems for an analogies hypothesis. The number of Common Letter words read correctly at Analogy test in the unrepeated clue stories was significantly smaller than the number of Analogous Beginning and Analogous End words read correctly (1.69 vs. 2.19 and 2.86 respectively, $p's < 0.01$), and so can probably be put down to a random effect. The improvement made on the Analogous words by the children in the unrepeated clue stories was equivalent to that made by the children in the repeated clue stories, who read 2.24 and 2.55 Analogous Beginning and End words correctly at Analogy test respectively. The only effect of repeating the clue word as far as analogy was concerned was that children receiving the repeated clue stories did not read significantly more Analogous End words than Analogous Beginning words correctly at

Analogy test (2.55 vs. 2.24), while the children receiving the unrepeated clue stories did (2.86 vs. 2.19). This is difficult to explain, but seems unlikely to be due to not repeating the clue word.

The unexpected difference found between the Analogous End words and the other wordtypes at Pretest also complicates the interpretation of the significant interaction found between Condition, Test and Wordtype ($F(2,70) = 9.27, p < 0.001$). It was predicted that such an interaction should be due to a significant improvement in reading the Analogous words in the With Title condition only. Post-hoc tests (Newman-Keuls) confirmed that there was a significant improvement in reading both the Analogous Beginning and the Analogous End words from Pretest to Analogy test in the With Title condition (0.82 vs. 2.67 and 1.49 vs. 3.36 respectively, $p's < 0.01$). The Analogous Beginning words also improved significantly in the Without Title condition (1.05 vs. 1.77, $p < 0.01$), but significantly less than in the With Title condition (1.77 vs. 2.67, $p < 0.01$). Thus the results did fit the predictions. However, the Analogous End words were read significantly better than the Analogous Beginning and Common Letter words at Pretest in both conditions (Title: 1.49 vs. 0.82 and 0.97; Without Title: 1.62 vs. 1.05 and 0.87 respectively, $p's < 0.01$). This makes interpretation of the Analogy test scores difficult. Significantly more Analogous End words were read correctly at Analogy test than Analogous Beginning words (3.36 vs. 2.67, $p < 0.01$), but this could have been due to the Analogous End words being intrinsically easier anyway, since they were already easier at Pretest. In order to examine performance at Analogy test once the influence of Pretest differences in reading the different wordtypes had been removed, it was decided to carry out an analysis of covariance on the number of words read correctly, taking the

number of words read at Pretest as the covariate.

Analysis 2: Analysis of Covariance

To establish that the analogy effects were not caused by the Analogous End words being intrinsically easier to read than the other wordtypes, an analysis of covariance was performed. Taking the Pretest scores as a covariate results in Analogy test performance being adjusted to take initial reading levels of the different wordtypes into account. By analysing the Analogy test scores once they have been adjusted for Pretest differences, it can be established whether the effects of making analogies are independent of differences at Pretest. A $2 \times 2 \times 2 \times 3$ (Order $\times$ Repeated Clue $\times$ Condition (With Title and Without Title) $\times$ Wordtype (Analogous Beginning, Analogous End and Common Letter)) Ancova was thus carried out with repeated measures on Condition and Wordtype. The number of words read correctly at Analogy test was the dependent variable, and the number of words of each wordtype read correctly at Pretest was the covariate.

If analogies were being made from the clue words in the With Title condition to the Analogous words in the stories, an interaction between Condition and Wordtype would be predicted, as more Analogous Beginning and Analogous End words should be read correctly in the With Title condition than in the Without Title condition, but the number of Common Letter words read correctly should not differ with condition. The full Ancova table is given in Table 11.4 (overpage).

Table 11.4

Analysis of covariance on the number of words read correctly
at Analogy test in Experiment 8

	Sum of Sq.	d.f.	Mean Sq.	F	P.
1. Order (O)	3.22	1	3.21	1.20	n.s.
Rep. Clue(RC)	1.82	1	1.82	0.68	n.s.
O x RC	2.26	1	2.26	0.84	n.s.
Covariate	167.67	1	167.67	62.56	0.0001
Error	91.13	34	2.68		
2. Condition(C)	40.91	1	40.91	28.94	0.0001
C x O	0.44	1	0.44	0.31	n.s.
C x RC	0.02	1	0.02	0.01	n.s.
C x O x RC	1.02	1	1.02	0.72	n.s.
Covariate	30.88	1	30.88	21.85	0.0001
Error	48.06	34	1.41		
3. Wordtype(W)	24.42	2	12.21	12.57	0.0001
W x O	1.67	2	0.83	0.86	n.s.
W x RC	3.48	2	1.74	1.79	n.s.
W x O x RC	2.98	2	1.49	1.53	n.s.
Covariate	14.04	1	14.01	14.43	0.0005
Error	66.99	69	0.97		
C x W	15.88	2	7.94	9.82	0.0005
C x W x O	1.07	2	0.54	0.66	n.s.
C x W x RC	2.17	2	1.08	1.34	n.s.
CxWxOxRC	5.32	2	2.66	3.29	0.05
Covariate	16.83	1	16.83	20.81	0.0001
Error	55.78	69	0.81		

The Ancova showed a significant main effect of Condition ($F_{(1,34)} = 28.94, p < 0.0001$), which was caused by significantly more words being read correctly in the With Title condition than in the Without Title condition, (2.69 vs. 1.73). There was also a significant main effect of Wordtype ($F_{(2,69)} = 12.57, p < 0.0001$), which was caused by significantly more Analogous Beginning and End words being read correctly than Common Letter words (2.33 and 2.44 vs. 1.71, p 's < 0.01, Tukey's). The number of Analogous Beginning and End words read correctly did not differ significantly. The finding that the covariate was significant at all levels confirms that there was a relationship between Pretest and Analogy test scores, and

justifies using the Pretest scores as a covariate. The adjusted means are given in table 11.5. The table shows that performance in the With Title condition was superior to performance in the Without Title condition for the Analogous words only.

Table 11.5

Adjusted means for the number of words read correctly at
Analogy test out of 6

	<u>Repeated Clue</u>			<u>Unrepeated Clue</u>		
	<u>Beg.</u>	<u>End</u>	<u>CL</u>	<u>Beg.</u>	<u>End</u>	<u>CL</u>
<u>With Title</u>	3.03	3.09	1.42	2.68	3.18	2.12
<u>Without Title</u>	1.86	1.47	1.60	1.78	2.00	1.73

A significant interaction between Condition and Wordtype ($F_{(2,69)} = 9.82, p < 0.0005$) was also found. This shows that analogies were being made. Post-hoc tests (Newman-Keuls) showed that significantly more Analogous Beginning and End words were read correctly in the With Title condition than in the Without Title condition (2.85 vs. 1.81 and 3.14 vs. 1.74 respectively, p 's < 0.01). The number of Common Letter words read correctly in the two conditions did not differ (1.76 and 1.65). This shows that children were making analogies to both the Analogous Beginning and Analogous End words. However, there was no sign of the End effect found in previous studies, as the number of Analogous Beginning and Analogous End words read correctly in the With Title condition did not differ (2.85 and 3.14). This means that the End effect found in the first Anova could be explained as the result of the Analogous End words

being intrinsically easier to read. This finding suggests that analogies between the beginnings and the ends of words are equally useful in prose reading. This raises the intriguing possibility that the End effect found in previous experiments was due to the presentation of words in isolation.

An interaction was also found between Condition, Wordtype, Order and Repeated Clue ($F(2,69) = 3.29, p < 0.05$). This suggests that analogies were made differently depending on order and repeated clue. Post-hoc analysis of the interaction showed that the number of analogies made to the Analogous End words differed with order and repeated clue. Significantly more Analogous End words were read correctly in the With Title condition than in the Without Title condition by the children in Order Group 1 (With Title first) who received the repeated clue stories, and by the children in Order Group 2 (Without Title first) who received the unrepeated clue stories (3.31 vs. 1.45 and 3.55 vs. 1.47 respectively, $p's < 0.05$). This is difficult to interpret theoretically, and was the only difference between the different order groups found. This suggests that overall analogies were not being made differently depending on order and repeated clue, as patterns of performance were otherwise very similar.

Discussion

It can be concluded that analogies were used to read new words in normal prose reading. The effect of analogy was independent of the effect of context, and acted to enhance performance above the levels achieved by using context alone. While this may be partly due to the fact that the stories used were written in such a way that context could not unambiguously determine the identity of unknown words, this

shows that context is not always a useful cue to use in decoding new words encountered when reading text. Analogy is obviously an important strategy for reading new words, and is used by young children during normal prose reading, and not just when new words are presented in isolation with an analogous clue word.

The fact that similar analogy effects were found in passages of prose and in the experiments with isolated words suggests that it is permissible to make claims about the reading process from the single word experiments reported here. The weight of the evidence presented in this thesis has shown that analogy is a very important strategy in decoding new words. The only difference between the previous experiments and the experiment reported here seems to be that in reading prose the End effect disappears, as the improvement in reading the Analogous Beginning words was the same as that found for the Analogous End words. This suggests that one artifact of presenting single words to read in isolation may be to exaggerate the importance of analogies between the ends of words. In normal prose reading analogies between the beginnings of words are made as frequently as analogies between the ends of words.

One way to examine the processes which underlie the successful use of analogy in reading is to ask exactly how analogy as a strategy might operate. Analogy helps children to assign the correct sound patterns to words which share similar spelling patterns. As such, it may be either a visual or an orthographic mechanism, depending on either word shape or on letter conjunction; or it may depend on a combination of both visual and orthographic processes. A final experiment was carried out in order to try and distinguish between these alternatives. This is reported in Chapter 12.

CHAPTER TWELVETHE PROCESSES UNDERLYING THE USE OF ANALOGIES IN READING

The aim of this chapter is to examine the processes underlying the use of analogies in reading. When a child makes an analogy from a known word to a new word in reading, she is making a prediction about the sound of the new and unknown word. This prediction is based on a comparison between the spelling pattern of the unknown word and the spelling pattern of a word of similar appearance which she already has in her reading vocabulary. Thus analogy in reading is fundamentally a way of assigning sound patterns across words.

The basis for assigning sound to an unknown word by analogy to a known word is the similarity in spelling shared by the two words forming the analogy. Hence there are two processes which might underlie the use of analogies in reading, both of which contribute to the recognition of similarities in spelling. The first is a visual process: the child might use a comparison between the visual appearance of the two words (or parts of the two words) as a basis for making the analogy. The second process which might underlie the use of analogy is an orthographic one. Rather than rely on the visual appearance of the two words, the child might make analogies on the basis of letter conjunction, irrespective of whether the two words have a similar appearance or not.

Of course, in normal reading the two processes will usually operate simultaneously, as two words which share a common spelling pattern will also share a similarity in visual appearance. However, occasionally a word may be written partially in capital letters (say,

a real name), and so an analogy may be needed between two words which differ somewhat in visual appearance. Hence an interesting question is the degree to which the use of analogies in reading depends on the use of visual, orthographic, or visual and orthographic information.

Clearly, the most likely possibility is that both visual and orthographic information are important for analogy to operate. However, the two processes might operate differently depending on whether analogies must be made between the beginnings or between the ends of words. One of the experiments reviewed in Chapter 4.2.i. is partially relevant to this question.

Santa (1977) presented children with words to match to a target which were visually distorted in a number of ways (e.g. BLAST: B-LAST, BL-AST, BLA-ST). She found a strong effect of onset-rime divisions on recognition time: words divided at the onset-rime boundary (e.g. BL-AST) were recognised as quickly as whole words (BLAST). Santa's results predict that the kind of visual/orthographic segmentation of a word required for analogies between the ends of two words is simpler for the child to make than the kind of segmentation required for analogies between the beginnings of two words. However, whether this is a purely visual effect or whether it has a strong orthographic component cannot be determined from her experiment.

One way of looking at whether Santa's effects are dependent on a visual or on an orthographic strategy would be to repeat her experiment using case alternation. Case alternation involves mixing upper and lower case within the same word, thus distorting visual information while keeping orthographic information constant. For example, if Santa had asked children to match words which alternated in case at different intra-word boundaries (e.g. BLAST: BL-ast,

bla-ST) and had found exactly the same effects as previously, this would imply that orthographic information was underlying the matching process rather than visual information. A similar technique can be used to investigate whether analogy depends on a visual or on an orthographic mechanism. This technique was used in the present experiment.

If children are asked to make analogies between words which vary in letter case, they must rely on an orthographic strategy, as the visual information in the words is distorted. Thus to make an analogy between 'BeAk' and 'bEaN', a child cannot use visual cues. A comparison between the number of analogies made when the stimuli are presented in mixed case (e.g. BeAk-bEaN) with the number of analogies made when the stimuli are presented in the same case (e.g. BeAk-BeAn) can provide information about the relative importance of visual and orthographic strategies for making analogies in reading. Such a comparison is not confounded by the use of phonological processes, as these will be equivalent in both conditions.

Experiment 9 made this comparison by using the word game designed to look at the use of analogy in Experiments 2 and 3. The word game was played exactly as before, the child receiving a 'clue' word from which analogies could be made. The only difference was that the clue word was either written in the same case as the words to which analogies could be made, or in a different case. If analogy is based largely on visual processes, more analogies should be made in the same case condition than in the mixed case condition, as only the same case condition provides the children with visual cues. If analogy relies more on orthographic processes, then analogies should be made as frequently in the mixed case condition as in the same case

condition, as both conditions provide orthographic cues. However, if the use of visual and orthographic information differs depending on whether analogies must be made between the beginnings or between the ends of words, then this should show up when the two conditions are compared.

Experiment 9: The Contribution of Visual and Orthographic Information to Analogies in Reading

Experiment 9 was very similar in design to Experiments 2 and 3. The same wordgame was played using the same words as were used previously. The only difference was that instead of comparing performance in conditions where analogies could be made between either the beginnings or the ends of words (or not at all), Experiment 9 compared the number of analogies made between both the beginnings and the ends of words when the clue word was either in the same case as the test words, or when the clue and test words were in a mixture of letter cases.

Method

Subjects

32 children from the infant classes of a local primary school took part in the study. The Schonell Graded Word Reading Test and the British Picture Vocabulary Scales were given as usual to assess reading level and verbal ability. Nine of the children did not yet score on the test, and so were effectively non-readers. The mean age of the whole group was 6;4 yr., range 5;2 - 7;4 yr., the mean reading age of the readers was 6;8 yr., range 6;2 - 7;4 yr. The mean BPVS score was 110.7, s.d. 15.6.

Procedure

The children played the word game used in Experiments 2 and 3, the only differences being that some of the words were written in mixed case, and that Beginning and End Analogous words were presented within the same condition (as in Experiment 4). As the method used was virtually identical to that used in Experiments 2 and 3, it will only be briefly outlined. The children were seen three times, once for a Pretest, and twice for Analogy sessions, a different condition being given in each session. The procedure followed in each Analogy session was identical.

Pretest

In the Pretest, all the children in the infant classes of the school (56 children) were given all the test words used in the study to read, mixed with other words suitable for six year old readers. Only children who could not already read most of the words were selected for the study (32 children).

Analogy sessions

In the Analogy sessions, the children were told that they were going to play a game about working out words, and that some of the words would be in "funny writing". In each session, the child was given a 'clue' word printed on a card, such as 'beak', which the experimenter read for her. Nine test words were then placed one by one in random order below the clue word for the child to read. The words were printed in black type 1/2" high on white cards measuring 4" x 6", in a mixture of upper case and lower case. As before, each word was removed after the child had made an attempt at reading it.

Conditions

There were two conditions, Same Case and Mixed Case. In the Same Case condition, the clue and test words given were written in the same case; in the Mixed Case condition the clue word was in a different case from the test words and the test words were in a mixture of cases. The children received half of the words in the Same Case condition, and the other half in the Mixed Case condition. Two clue words and their nine associated test words were given in each condition. The words are explained more fully below.

Letter Case

Within these two conditions, four different types of letter case were used. The four types of letter case were designated as separate sets with respect to the design of the experiment. The four sets were:

1. Lower case - all the words were written in lower case, (beak-bean)
2. Upper case - all the words were written in upper case, (BEAK-BEAN)
3. Mixed case 1 - the words were written in alternating case, starting with lower case (bEaK-bEaN)
4. Mixed case 2 - the words were written in alternating case, starting with upper case (BeAk-BeAn)

For words with double consonants (e.g. 'speak'), the double consonant was kept in the same case, so that the orthographic sequence relevant to an analogy would be represented in the same way in all the words (e.g. 'spEaK' or 'SPeAk').

The four sets of letter case were used experimentally as follows. In the Same Case condition, the child was given clue and test words from either set 1, set 2, set 3, or set 4. This meant that

both clue and test words were written in the same case, whether this was purely upper or lower case (sets 1 or 2) or a mixture of the two. In the Same Case condition, the visual appearance of the words was thus constant across the orthographic sequences required for the analogies.

In the Mixed Case condition, the child was given either a clue word from set 1 and test words from sets 2, 3 and 4; a clue word from set 2 and test words from sets 1, 3 and 4; a clue word from set 3 and test words from sets 1, 2 and 4; or a clue word from set 4 and test words from sets 1, 2 and 3. This meant that the visual information varied between clue and test words, so that any use of analogy had to be based on letter conjunction (orthographic strategies). To control for the word sets being of differential difficulty (reading 'BeAk' may be harder than reading 'BEAK'), a given child acted as her own control. If the child received set 1 words in the Same Case condition, then the clue word in the Mixed Case condition was also from set 1; whereas if the child received set 2 words in the Same Case condition, then the clue word in the Mixed Case condition was from set 2, and so on. Hence if a given subject had particular difficulty with a given letter case, this difficulty was equated across conditions.

Words

There were three types of test words, Analogous Beginning (bean), Analgous End (peak), and Common Letter (bask). Exactly the same Analogous and Common Letter words were used as in Experiment 2, but only four of the six word sets used in Experiment 2 were employed. These were the sets for the clue words 'beak', 'hark', 'seen', and 'coat'. The sets for the clue words 'rail' and 'skin'

were not used as the capital letter 'i' is easy to confuse with a lower case 'l', and it was felt that this would unnecessarily add to the complexity of the experimental task.

In order to counterbalance the order of the word sets and conditions, the children were split into two groups of 16 matched for age and reading age. The word sets were paired, so that the 'beak' and 'hark' words were always presented in the same session, as were the 'seen' and 'coat' words. Each session was conducted on a different day. The children received the word sets and conditions in different counterbalanced orders. In addition, the letter case set was varied so that across the experiment as a whole all the orthographic subsets were used an equal number of times. This required a group of 16 subjects to fulfill all the combinations of letter case with the different orders of receiving the word sets and conditions. As 32 subjects were used in all, the design was fully balanced.

Predictions

If children can make analogies between words in reading, a significant improvement in reading the Analogous words at Analogy test compared to Pretest would be predicted, with a corresponding lack of improvement in reading the Common Letter words, as found in previous experiments. However, if analogies depend on visual processes rather than on orthographic processes, an improvement on the Analogous words compared to Pretest should only be found in the Same Case condition. No improvement would be expected in the Mixed Case condition, where visual cues for analogy cannot be used. If orthographic processes play the major role in the use of analogies in reading, an equal improvement in reading the Analogous words at

Analogy test would be expected in both conditions, as orthographic cues are available in both the Same Case and the Mixed Case conditions.

In addition, if orthographic and visual cues are equally important in making analogies between both the beginnings and the ends of words, the improvement in reading the Beginning and End Analogous words should be the same in both conditions. However, if visual cues play a greater role in making analogies between the beginnings of words than in making analogies between the ends of words, more analogies should be made between the beginnings of words in the Same Case condition than in the Mixed Case condition, but the number of analogies made between the ends of words should be the same in both conditions. Similarly, if making analogies between the ends of words depends more on visual cues than making analogies between the beginnings of words, the reverse pattern of results would be expected. More analogies should be made between the ends of words in the Same Case condition than in the Mixed Case condition, but the number of analogies made between the beginnings of words should be the same in both conditions.

Results

Analysis 1: Number of words read correctly

The mean number of words read correctly in the two conditions is given in Table 12.1 (overpage), separated by wordtype. As can be seen, there is a big improvement in the number of Analogous words read correctly in both conditions, but not in the number of Common Letter words read correctly. The magnitude of the improvement seems to be similar in both conditions.

Table 12.1

Mean number of words read correctly in experiment 9 out of 6

<u>Condition</u>	<u>Same Case</u>			<u>Mixed Case</u>		
<u>Wordtype</u>	<u>Beg.</u>	<u>End</u>	<u>CL</u>	<u>Beg.</u>	<u>End</u>	<u>CL</u>
Pretest	0.50	0.75	0.44	0.47	0.44	0.41
	(1.05)	(1.39)	(1.01)	(0.80)	(0.95)	(0.84)
Analogy	2.72	4.03	0.75	2.06	4.13	0.84
	(1.92)	(1.99)	(0.91)	(1.85)	(1.72)	(0.99)

Note. Standard deviations in parentheses.

To check this interpretation, a 2 x 4 x 3 x 2 x 3(Order group x Letter Case (Lower, Upper, Mix1, Mix2) x Condition (Same vs. Mixed Case) x Test (Pretest vs. Analogy test) x Wordtype (Analogous Beginning, Analogous End, and Control)) Anova was carried out on the number of words read correctly, with repeated measures on Condition, Test and Wordtype. The number of words read correctly was the dependent variable. If analogies were being made, an interaction between Test and Wordtype would be predicted, as children should read more Analogous words correctly at Analogy test than at Pretest, but should not read more Common Letter words correctly. If analogies were made more frequently in one condition than in the other, or if analogies were only being made in one of the conditions, an interaction between Condition, Test and Wordtype would be predicted, as more Analogous words should be read correctly at Analogy test than at Pretest in one of the two conditions only, but this difference

should not extend to the Common Letter words. This interaction should also demonstrate whether the number of analogies made between the beginnings and the ends of words differs with condition.

Finally, if analogies were affected by the letter case set which the child received, an interaction between Test, Wordtype and Letter Case would be predicted, as analogies should vary with letter case. If analogies were affected by letter case depending on Condition, an interaction between Condition, Test, Wordtype and Letter Case would be predicted, as more Analogous words should be read correctly at Analogy test for some letter cases in one of the conditions only. The full Anova table is given in Table 12.2 (overpage).

The Anova showed a significant main effect of Order ($F(1,24) = 4.72, p < 0.05$). This showed that the order of receiving the different conditions was having an effect on the number of words read correctly, an effect which was not predicted. The children who received the Mixed Case condition first read on average 1.79 words correctly, whereas the children who received the Same Case condition first read on average 1.14 words correctly.

The Anova also showed a significant main effect of Test ($F(1,24) = 164.12, p < 0.0001$). This was due to significantly more words being read correctly at Analogy test than at Pretest (2.42 vs. 0.50). There was also a significant main effect of Wordtype ($F(2,48) = 70.53, p < 0.0001$). This was due to significantly more End Analogous words being read correctly than Beginning Analogous words (2.35 vs. 1.44, $p < 0.01$), and significantly more Beginning Analogous words being read correctly than Common Letter words (1.44 vs. 0.61, $p < 0.01$) (Tukey's).

Table 12.2

Analysis 1: Anova on the number of words read correctly in
Experiment 9: Order and Case

	Sum of Sq.	d.f.	Mean Sq.	F	P.
1. Order (O)	40.69	1	40.69	4.72	0.05
Case (Ca)	47.74	3	15.91	1.84	n.s.
O x Ca	4.47	3	1.49	0.17	n.s.
Error	207.10	24	8.63		
2. Condition(C)	1.90	1	1.90	1.43	n.s.
C x O	0.02	1	0.02	0.02	n.s.
C x Ca	1.30	3	0.43	0.33	n.s.
C x O x Ca	2.92	3	0.97	0.74	n.s.
Error	31.77	24	1.32		
3. Test (T)	354.59	1	354.59	164.12	0.0001
T x O	22.52	1	22.52	10.42	0.005
T x Ca	4.57	3	1.52	0.71	n.s.
T x O x Ca	6.72	3	2.24	1.04	n.s.
Error	51.85	24	2.16		
C x T	0.02	1	0.02	0.02	n.s.
C x T x O	0.07	1	0.07	0.05	n.s.
C x T x Ca	6.51	3	2.17	1.73	n.s.
CxTxOxCa	1.30	3	0.43	0.35	n.s.
Error	30.02	24	1.25		
4. Wordtype(W)	190.89	2	95.45	70.53	0.0001
W x O	4.94	2	2.47	1.83	n.s.
W x Ca	3.69	6	0.62	0.45	n.s.
W x O x Ca	2.68	6	0.45	0.33	n.s.
Error	64.96	48	1.35		
C x W	2.30	2	1.15	2.16	n.s.
C x W x O	0.77	2	0.38	0.72	n.s.
C x W x Ca	6.66	6	1.11	2.09	n.s.
CxWxOxCa	5.57	6	0.93	1.74	n.s.
Error	25.54	48	0.53		
T x W	154.70	2	77.35	59.93	0.0001
T x W x O	6.67	2	3.34	2.58	n.s.
T x W x Ca	2.05	6	0.34	0.26	n.s.
TxWxOxCa	7.12	6	1.19	0.92	n.s.
Error	61.96	48	1.29		
C x T x W	4.55	2	2.27	4.04	0.05
CxTxWxO	0.35	2	0.17	0.31	n.s.
CxTxWxCa	2.58	6	0.43	0.76	n.s.
CxTxWxOxCa	4.32	6	0.72	1.28	n.s.
Error	27.04	48	0.56		

The Anova also showed a number of significant interactions. The

two-way interactions will be discussed first. The interaction between Test and Wordtype ($F(2,48) = 59.93, p < 0.0001$) showed that analogies were being made. Post-hoc testing showed that the number of Analogous Beginning and Analogous End words read correctly at Analogy test was significantly greater than the number of Analogous Beginning and Analogous End words read correctly at Pretest (2.39 and 4.08 vs. 0.48 and 0.59 respectively, $p's < 0.01$), whereas performance on the Common Letter words did not improve significantly (0.80 vs. 0.43). This is exactly the pattern of results that would be predicted if children were using analogies, and so the Test x Wordtype interaction is evidence that the children were making analogies in reading.

The interaction between Order and Test was also significant ($F(1,24) = 10.42, p < 0.005$), which was not predicted. Post-hoc tests (Newman-Keuls) showed that the children in both Order Groups improved significantly from Pretest to Analogy test (Group I from 0.58 to 2.99, and Group II from 0.42 to 1.85, $p's < 0.01$). However, the children in Order Group I read significantly more words correctly than the children in Order Group II at Analogy test ($p < 0.01$), while the two groups did not differ at Pretest. Order Group I received the Mixed Case condition first, and Order Group II the Same Case condition first. This suggests that more analogies were made by the children who received the Mixed Case condition first. This finding is difficult to interpret.

Finally, a significant interaction was found between Condition, Test and Wordtype ($F(2,48) = 4.04, p < 0.05$). This suggests that more analogies were being made in one condition than in the other. However, post-hoc tests (Newman-Keuls) showed that the cause of the interaction was more complex than this. The interaction was caused by

performance on the Analogous Beginning words in the Same Case condition being significantly better than performance on the Analogous Beginning words in the Mixed Case condition ($p < 0.01$). Performance on the Analogous End words improved equally in both conditions, and performance on the Common Letter words did not improve in either condition.

This shows that children made analogies between the ends of words as frequently if the words were written in mixed case as if the words were written in the same case. However, children made more analogies between the beginnings of words written in the same case than between the beginnings of words written in mixed case. This suggests that analogies between the beginnings of words rely to some extent on visual strategies, whereas analogies between the ends of words rely largely on orthographic strategies. This is an interesting finding, as it suggests that visual and orthographic strategies may be used to a different extent in analogies between the beginnings and the ends of words.

The use of orthographic and visual cues and reading level

We will now turn to the question of whether analogies with same case and mixed case stimuli are influenced by reading level. It is possible that non-readers may rely to a different extent on orthographic and on visual strategies than readers do when making analogies. It is also possible that children at different reading levels may behave differently with the different letter cases. To examine these possibilities, an Anova taking Case and Reading Level as the between-groups factors was run. It was not possible to combine all three between-group factors (i.e. Order, Case and Reading Level) within one analysis, as there were too few non-readers to fill all

the different cells necessitated by such a large analysis. Another Anova was thus also run, which took Order and Reading Level as the between-groups factors. However, although an effect of Order had been found in the overall analysis, no Order effects were found when Reading Level was included as a between-subjects variable. Hence only the Anova for Case and Reading Level will be reported here. In discussing this analysis, only the results which were not found in the original Anova will be examined in detail.

Analysis 2: Letter Case and Reading Level

A second analysis was thus run to examine whether the number of analogies made by the non-readers and by the readers would vary with letter case. A $2 \times 4 \times 2 \times 2 \times 3$ (Reading Level (Non-readers vs. Readers) $\times$ Case (Upper, Lower, Mix1, Mix2) $\times$ Condition (Same Case and Mixed Case) $\times$ Test (Pretest $\times$ Analogy test) $\times$ Wordtype (Analogous Beginning, Analogous End and Common Letter)) Anova with repeated measures on Condition, Test and Wordtype was run, taking the number of words read correctly as the dependent variable.

As analogies were being made, an interaction between Test and Wordtype would again be predicted. If the number of analogies made by both the non-readers and the readers differed depending on letter case, an interaction between Test, Wordtype and Letter Case would be predicted, as more Analogous words should be read correctly in the Analogy test for some letter cases only. If the number of analogies made by the readers differed from the number of analogies made by the non-readers depending on letter case, an interaction between Test, Wordtype, Letter Case and Reading Level would be predicted, as the number of Analogous words read correctly at Analogy test in the different letter cases should differ with reading level.

However, the effects of letter case could interact with condition. If the number of analogies made in the different conditions by both the readers and the non-readers differed with letter case, an interaction between Condition, Test, Wordtype and Letter Case would be predicted, as more Analogous words should be read correctly at Analogy test in one condition than in the other for some letter cases only. Finally, if the number of analogies made by the readers differed from the number of analogies made by the non-readers for both condition and letter case, an interaction between Condition, Test, Wordtype, Letter Case and Reading Level would be predicted, as more Analogous words should be read correctly at Analogy test by the readers than by the non-readers in one condition than in the other depending on letter case. The full Anova table is given in Table 12.3 (overpage).

The Anova showed a significant main effect of Case ($F(3,24) = 6.78, p < 0.005$). This indicates that the number of words read correctly varied with letter case. Post-hoc tests (Tukey's) showed that the effect was due to significantly more words written in Mixed Case 2 (BeAk) being read than words written in Upper Case or in Mixed Case 1 (2.05 vs. 1.14 and 1.27 respectively, $p < 0.01$), or in Lower Case (2.05 vs. 1.39, $p < 0.05$). The number of words written in Upper Case, Lower Case and Mixed Case 1 did not differ significantly.

There was also a significant main effect of Reading Level ($F(1,24) = 76.31, p < 0.0001$), which was caused by the readers reading significantly more words correctly than the non-readers (1.86 vs. 0.44). There was also a significant main effect of Test ($F(1,24) = 142.67, p < 0.0001$), caused by significantly more words being read correctly at Analogy test than at Pretest, and a significant main

effect of Wordtype ($F(2,48) = 53.87, p < 0.0001$), caused by more Beginning and End Analogous words being read correctly than Common Letter words, as in Analysis 1.

Table 12.3

Anova: number of words read correctly in Experiment 9: Case and Reading Level

	Sum of Sq.	d.f.	Mean Sq.	F	P.
1. Case (Ca)	45.73	3	15.24	6.78	0.005
Reading(RL)	171.48	1	171.48	76.31	0.0001
C x RL	16.70	3	5.57	2.48	n.s.
Error	53.93	24	2.25		
2. Condition(C)	1.08	1	1.08	0.87	n.s.
C x Ca	0.38	3	0.13	0.10	n.s.
C x RL	0.74	1	0.74	0.59	n.s.
C x RL x Ca	3.84	3	1.28	1.03	n.s.
Error	29.79	24	1.24		
3. Test (T)	183.72	1	183.72	142.67	0.0001
T x Ca	2.75	3	0.92	0.71	n.s.
T x RL	43.58	1	43.58	33.85	0.0001
T x Ca x RL	9.74	3	3.25	2.52	n.s.
Error	30.91	24	1.29		
C x T	0.02	1	0.02	0.02	n.s.
C x T x Ca	4.22	3	1.41	1.11	n.s.
C x T x RL	0.00	1	0.00	0.00	n.s.
CxTxCaRL	1.01	3	0.34	0.27	n.s.
Error	30.37	24	1.27		
4. Wordtype(W)	111.75	2	55.88	53.87	0.0001
W x Ca	7.44	6	1.24	1.20	n.s.
W x RL	14.98	2	7.49	7.22	0.005
W x Ca x RL	8.26	6	1.38	1.33	n.s.
Error	49.79	48	1.04		
C x W	1.69	2	0.85	1.50	n.s.
C x W x Ca	2.75	6	0.46	0.81	n.s.
C x W x RL	0.90	2	0.45	0.80	n.s.
CxWxCaxRL	3.66	6	0.61	1.08	n.s.
Error	27.12	48	0.57		
T x W	92.96	2	46.48	45.43	0.0001
T x W x Ca	3.08	6	0.51	0.50	n.s.
T x W x RL	9.88	2	4.94	4.83	0.01
TxWxCaxRL	16.99	6	2.83	2.77	0.05
Error	49.11	48	1.02		
C x T x W	3.27	2	1.63	2.73	n.s.
CxTxWxCa	0.83	6	0.14	0.23	n.s.
CxTxWxRL	0.09	2	0.05	0.08	n.s.
CxTxWxCaxRL	2.85	6	0.47	0.79	n.s.
Error	28.71	48	0.60		

The Anova also showed a number of significant interactions. There was a significant interaction between Test and Wordtype ($F(2,48) = 45.43, p < 0.0001$), as previously, showing that analogies were being made, and a significant interaction between Test and Reading Level ($F(1,24) = 33.85, p < 0.0001$). This was caused by both the readers and the non-readers reading more words correctly at Analogy test than at Pretest (Readers: 3.03 vs. 0.70; Non-readers 0.87 vs. 0.00, $p's < 0.01$). The readers also read significantly more words correctly than the non-readers at both Pretest and Analogy test ($p's < 0.01$). Hence the interaction between Test and Reading Level largely restates the main effects found for Test and Reading Level.

There was also a significant interaction between Wordtype and Reading ($F(2,48) = 7.22, p < 0.005$). Post-hoc tests (Newman-Keuls) showed that the readers read significantly more End Analogous words correctly than Beginning Analogous words (2.83 vs. 1.91, $p < 0.01$), and also significantly more Beginning Analogous words correctly than Common Letter words (1.91 vs. 0.85, $p < 0.01$). The non-readers also read more End Analogous words correctly than Beginning Analogous words (1.08 vs. 0.22, $p < 0.01$), but did not read more Beginning Analogous words correctly than Common Letter words (0.22 vs. 0.00). Hence only the readers were reading significantly more Analogous Beginning words correctly than Common Letter words.

A significant interaction between Test, Wordtype and Reading Level ($F(2,48) = 4.83, p < 0.01$) was also found. This suggests that more analogies were made by the readers than by the non-readers. Post-hoc tests (Newman-Keuls) showed that the readers read significantly more Beginning and End Analogous words correctly at

Analogy test than at Pretest (3.15 and 4.83 vs. 0.67 and 0.83 respectively, $p's < 0.01$), but did not read more Common Letter words correctly at Analogy test than at Pretest (0.59 vs. 1.11). The non-readers only read more End Analogous words correctly at Analogy test compared to Pretest (2.17 vs. 0.00, $p < 0.01$). Performance on the Beginning Analogous words and on the Common Letter words did not improve from Pretest to Analogy test (0.00 to 0.44 and 0.00 to 0.00 respectively). Thus the interaction was due to the readers making analogies between both the beginnings and the ends of words, while the non-readers only made analogies between the ends of words. This shows that only the readers were making a significant number of analogies to the Beginning Analogous words, as found in Experiment 3.

Finally, there was a significant interaction between Test, Wordtype, Letter Case and Reading ($F(2, 48) = 2.77$, $p < 0.05$). This suggests that analogies were made differently by the readers and by the non-readers depending on letter case. This interaction proved too difficult to interpret using post-hoc tests. However, informal inspection of the interaction showed that both the readers and the non-readers showed a strong End effect for all the letter cases used, and that the readers improved in reading the Beginning Analogous words in all the letter cases. The End effect shown by the non-readers for Mixed Case 2 was especially strong, being twice as large as the End effect found in the other letter cases. This is the most likely explanation of the interaction.

Thus the performance patterns of the readers and the non-readers with the different letter cases were very similar to those found in previous experiments. The readers read more Beginning and End Analogous words correctly in the Analogy test than in the Pretest

whatever letter case was used, and showed an End effect in all the letter cases (more analogies between the ends of words than between the beginnings of words), while the non-readers showed an End effect in all the letter cases but did not improve very much on the Beginning Analogous words.

Overall Discussion

In general it can be concluded that analogies are made in the same way for words written in mixed letter case as for words written in the same letter case, which implies that analogy is largely an orthographic mechanism. There is a visual component, however, as shown by the interaction with Condition (Same/Mixed case) on the overall Anova, but this seems mainly to be restricted to analogies between the beginnings of words, and is a small and apparently unreliable effect. In fact it is the similarities between the results of this experiment and the other experiments conducted in this thesis which are most striking: the maintenance of the End effect, the non-readers making a significant number of analogies between the ends but not the beginnings of words, and the overall similarity of performance by readers and non-readers irrespective of reading level. Analogy is therefore an important strategy in early reading development, and one not easily disrupted by the visual appearance of words.

Santa's (1977) finding that children are as quick to recognise words divided into onset and rime (BL-AST) as to recognise complete words (BLAST) was taken as a basis for suggesting that the orthographic segmentation required for analogies between the ends of words was very easy for young children to make. However, whether this segmentation was visually or orthographically based could not be

discovered from Santa's study. The results found here demonstrate that dividing words into onset and rime is an orthographic mechanism, as both the readers and the non-readers showed a strong End effect which was maintained across all letter cases. Both the readers and the non-readers made fewer analogies between the beginnings of words than between the ends of words, and only the readers made a significant number of analogies between the beginnings of words. However, both groups respectively performed in exactly the same way for all the letter cases. This suggests that beginning analogies also depend largely on an orthographic mechanism.

Clearly, then, orthographic rather than visual strategies underlie the use of analogies to read new words. This shows that young children quickly become very sophisticated in their approach to written language. If the kinds of visual strategies of word recognition proposed by many workers (e.g. Gough and Hillinger, 1980; Marsh, Friedman, Welch and Desberg, 1980a; Masonheimer, Drum and Ehri, 1984) operate in early reading (with young children recognising words on the basis of visual features which do not discriminate uniquely between words, e.g. 'camel' is the word with two humps in the middle), they are quickly abandoned for strategies which take into account the conjunction of the letters in words. Children are already using orthographic strategies to recognise and to distinguish between words before they begin to read formally, as even non-readers can make analogies between words. The use of orthographic information rather than visual information in decoding print is the key to becoming a reader, as the use of orthographic information in words is necessary to understanding the alphabetic code and using it to make predictions about the pronunciation of new words. To use alphabetic information efficiently, such information must be extracted from

written words irrespective of the visual appearance of these words. Such predictions include the use of analogies in reading, and so it is unsurprising (and encouraging) to find that analogies depend largely on orthographic processes.

CHAPTER THIRTEEN

CONCLUSIONS AND IMPLICATIONS

In order to discuss the conclusions and implications of the work presented in this thesis, the questions raised at the beginning of the thesis will be briefly repeated, and then the degree to which each question has been answered will be examined in turn. The limitations of the experiments will then be discussed, and finally the implications of the work presented here for future research will be considered.

13.1. The questions raised in this thesis

The first main question raised in this thesis was whether children in the beginning stages of learning to read and to spell are able to use an analogy strategy, or whether the use of analogy is limited to older children who are closer to the age of formal operations. The second main question was whether the use of an analogy strategy could explain the link between early skill in rhyming and later skill in reading and spelling. The third was whether analogies would be used differently in reading and in spelling.

13.2. The first question: Can analogies be used from the beginning of learning to read and spell?

As shown in Chapters 2 and 3, two separate areas of research are relevant to our first question. Much of the work in cognitive-developmental psychology reviewed in Chapter 2 on children's analogical reasoning ability has concluded that children

younger than 11-12 years of age should not be able to reason analogically. The claim is that analogical reasoning only emerges during the Piagetian period of formal operations, which begins in early adolescence.

Chapter 3 showed that the cognitive-developmental literature on the development of analogical reasoning has been largely ignored by those working in the field of reading and spelling development. Here two very different claims have been made concerning the development of the use of analogies to read and spell new words. Marsh and his co-workers (Marsh, Desberg and Cooper, (1977); Marsh, Friedman, Welch and Desberg, (1980a, 1980b); Marsh, Desberg, Friedman and Saterdahl, (1981); see Chapter 3.2) claimed that analogy is a developmentally sophisticated strategy which is only found in the final stage of reading and spelling development. In contrast, Baron (1977) argued that analogy is a strategy which comes naturally to young readers. However, as shown in Chapter 3.2 and 3.3, the evidence for both these claims is unconvincing.

The first four experiments presented in this thesis examined how early in development analogies are used by young children to read and spell new words. Experiment 1 showed that young children aged 6-7 years could use analogies between the spelling patterns at the beginnings of words to choose the correct spellings of new words which were read to them if an analogous ('clue') word was provided as a basis for the analogy. Even non-readers could make such analogies between the beginnings of words.

Experiment 2 showed that children aged 5-7 years could use analogies between the spelling patterns at the ends of words to read new words aloud when an analogous clue word was provided as a basis

for the analogy. The Analogous words were only read correctly in the presence of the correct clue word, and not when they acted as Control words for a different clue word. The improvement in performance was not due simply to shared grapheme-phoneme correspondences between the clue and test words, as other words which also had three letters in common with the clue words were not read successfully. This showed that the improvement was due to the use of analogy rather than to the number of shared letters in words per se. This time the children did not make a significant number of analogies to the beginnings of new words. Again, it was found that even some non-readers could make analogies between the ends of words.

Experiment 3 extended these findings by showing that there were no differences in the use of analogy by children at different reading levels, and that analogies could also be used to read nonsense words. In this more comprehensive experiment, it was shown that children could also use analogies between the spelling patterns at the beginnings of words to read new words aloud. Analogies between the ends of words were significantly easier, however, and the non-readers did not make any analogies between the beginnings of words. The failure to find any other developmental differences in the use of analogy was very striking.

Experiment 4 showed that 6-7 year old children could also make analogies in spelling when a clue word was provided as the basis for analogy. Although no developmental comparisons were made in this experiment, this suggested that analogy is also available in the beginning stages of learning to spell. Experiment 4 showed that, as in reading, analogies between the ends of words were significantly easier than analogies between the beginnings of words.

13.3. Conclusions regarding the first question

With respect to our first question, it can be concluded that analogy is not a developmentally sophisticated strategy characteristic of the final stages of learning to read and to spell, but is as important for children who are just beginning to learn to read and spell as it is for children who are already reading. The hypothesis of Marsh and his co-workers can therefore no longer be maintained. The finding that the use of analogies was not related to age or to reading level showed that Baron's hypothesis that analogies are used naturally by young readers is the correct one. Analogy is clearly a useful additional strategy to visual memory and phonological decoding, and is available from the very beginning of reading.

The results of Experiments 1-4 also showed that the conclusions reached by some workers in the cognitive-developmental field have been unduly pessimistic. Children's use of analogies to read and spell new words shows that they can make analogies long before they enter the stage of formal operations. This supports the recent evidence discussed in Chapter 2.6 regarding analogical reasoning in 4 and 5 year olds.

13.4. The second question: Does analogy explain the link between early rhyming skill and later reading and spelling ability?

As shown in Chapter 1.2 (and discussed in more detail in Chapter 4.4.v), words which rhyme are effectively categories of words which share common sounds, and these categories will often map onto categories of words which have common spelling patterns at the ends. It may be easier to learn that common orthographic sequences in words

can be used to predict that words will share common sounds if such rhyming categories are already present. This led to the hypothesis that the use of orthographic analogies could explain why children who are good at rhyming are later good at reading and spelling.

Experiment 3 provided strong support for this hypothesis. The results showed that children's rhyming skills were significantly related to the number of analogies which they made between both the beginnings and the ends of words in reading, even after the effect of verbal skills had been controlled. This relationship was significantly stronger than the relationship between phoneme deletion and analogies, a relationship which did not quite reach significance. The only disappointment was the failure to find a similar relationship between rhyming and reading for the non-readers. However, this may have been due to the small number of analogies made by the non-readers in Experiment 3.

Experiment 4 showed that a significant relationship also existed between rhyming skill and analogies between the ends of words in spelling, even after verbal skills had been partialled out. Experiment 4 also showed a significant relationship between children's use of alliteration and analogies between the beginnings of words. This was a nice result, as categorising words as sounding similar at the beginnings (alliteration) should be more strongly related to analogies between the beginnings of words, whereas categorising words as sounding similar at the ends (rhyme) should be more strongly related to analogies between the ends of words, as was found. The results of Experiment 4 suggested that analogy may also be the link relating early rhyming skills to later spelling development.

13.5. Conclusions regarding the second question

The hypothesis that the use of an analogy strategy may be the link in the pathway connecting early skill in rhyming with later skill in reading and spelling has thus received some support experimentally. It seems that the children who are good at rhyming are also the children who are good at using strings of letters in words to make predictions about common sounds, and at using common sounds in words to make predictions about spelling patterns.

13.6. The third question: Are analogies used differently in reading and in spelling?

It was argued in Chapter 1.2 that analogy may be used differently in reading and in spelling, as sound-to-spelling relationships are much less consistent than spelling-to-sound relationships. There are generally more ways of representing a given sound orthographically than there are of pronouncing a given orthographic sequence. Furthermore, inappropriate analogies can be prevented in reading (where they can result in nonsense words), but not in spelling, which might also affect the use of analogies. The question of how spelling-sound consistency affects children's willingness to make analogies in reading and in spelling was examined in Experiments 5, 6 and 7.

Experiment 5 showed that children were significantly affected by spelling-sound consistency in making analogies in reading. Children who were taught pairs of words which were inconsistent in sound but consistent in spelling (e.g. 'peak-steak') made significantly fewer analogies than children taught two unconnected words (e.g. 'peak-loan'). The latter made significantly fewer analogies than

children taught consistent pairs of words, such as 'peak-leak'. The strong effects found for spelling-sound consistency on the number of analogies made in reading showed that children were aware that analogy will not always be a useful strategy to use in reading new words. Children also made significantly more appropriate analogies (using 'peak' to read 'weak') than inappropriate analogies (using 'peak' to read 'break') in reading. This provided some support for the idea that the production of nonsense words could be used as a check for whether analogies were appropriate. However, this difference was already present at Pretest, and so the effect of the nonsense word check was confounded by prior knowledge.

Experiment 6 showed that spelling-sound consistency did not have a strong effect on the number of analogies made in spelling. Children made the same number of analogies to spell new words whether they learned pairs of words consistent (e.g. 'speak-leak'), inconsistent ('speak-steak'), or unconnected (e.g. 'speak-loan') in spelling and sound. Further support for this was found in Experiment 7, which showed that children could use knowledge gained in reading to mediate the use of analogies in spelling. The children made as many analogies when taught the inconsistent pairs of words used in Experiment 5 as they made when taught the consistent and unconnected pairs of words, even though they were taught to read rather than to spell these words. It was concluded that spelling-sound consistency only affects analogies in reading. In contrast to Experiment 6, children made as many appropriate analogies as inappropriate analogies in spelling in this experiment. This supported the idea that there is no check for the appropriateness of an analogy in spelling.

13.7. Conclusions regarding the third question

As far as our third question is concerned, therefore, it is clear that the effects of consistency differ depending on whether the task is one of reading or of spelling. Spelling-sound consistency is much more frequent in reading than in spelling, and so children use information about spelling-sound consistency to modify their use of analogies when the task is one of reading. Spelling-sound consistency is much less frequent in spelling, and in spelling tasks children ignore information about spelling-sound consistency, even when using spelling-sound knowledge gained through reading to make decisions about analogies in spelling.

The finding that children used information about spelling-sound consistency differently depending on the task which they were given suggested that their knowledge about English orthography was already quite sophisticated. Regarding the use of inappropriate analogies, it was clear that inappropriate analogies were made more frequently in spelling than in reading. This supported the hypothesis that in spelling there is no check that the use of analogy is appropriate.

13.8. Some limitations to the current studies

There were a number of limitations to the studies discussed so far, some of which it was possible to examine in the final experiments presented in this thesis, and some of which await further investigation. These will now be discussed.

13.8.i. The use of single words

Experiments 1 to 7 rely exclusively on the presentation of single words in isolation. They thus tell us nothing about how

children may behave when faced with reading sentences or passages of prose. This was felt to be an important issue, because children may have used analogy to read new words presented in isolation, but may not have used analogies when faced with the more usual classroom task of reading stories. Experiment 8 was designed to examine the role of analogy in normal prose reading.

Experiment 8 showed that children could use analogies to read new words which they encountered in the course of reading text. This shows that the reliance in earlier studies on single words was not a serious limitation. However, one difference between Experiment 8 and previous studies was that in prose reading analogies between the beginnings of words were as important as analogies between the ends of words, which contrasts with the strong End effect found in Experiments 2 and 3. One limitation of presenting words to read in isolation may therefore be to exaggerate the importance of analogies between the ends of words. In normal reading it seems that both beginning and end analogies are equally important.

13.8.ii. The processes underlying the use of analogy

Another limitation of experiments 1 to 7 is that they do not tell us how analogy as a strategy might operate. As argued in the introduction to Chapter 12, analogy could either rely on visual strategies or on orthographic strategies, or alternatively on a combination of the two. The contribution of visual and orthographic processes to analogies between both the beginnings and the ends of words was examined in Experiment 9.

In Experiment 9, children were asked to use analogies to read new words written in either the same letter case or in alternating

letter case, and the relative importance of visual and orthographic strategies was assessed by comparing children's performance on both types of words. This comparison showed that orthographic information was the major factor in making analogies between both the beginnings and the ends of words.

A similar pattern of results was found for the non-readers included in the experiment. Both the readers and the non-readers made the same number of analogies between words written in the same case as between words written in mixed case. This showed that even non-readers have a strong grasp of orthographic information in reading.

13.8.iii. Testing within stimuli as well as across stimuli

One weakness of the experiments presented in this thesis which has not yet been remedied is that comparisons were always made between stimuli rather than within stimuli. Analogies between the beginnings and the ends of words were compared by using the same clue word and different test words, instead of by using the same test words and different clue words. This may mean that the End effect found in the experiments using single words was due partly to the different words used rather than to differences in the use of analogies between the beginnings and the ends of words.

To rule out this alternative explanation of the End effect, an experiment is needed which asks children to make analogies to the beginnings and ends of the same test words through using different clue words. For example, test words like 'bean' could be given with clue words like either 'beak' (beginning analogies) or 'mean' (end analogies). This would test the beginning and end effects within

rather than across stimuli. If fewer analogies were still made between the beginnings of words than between the ends of words under these conditions, this would be evidence for a strong End effect in making analogies in reading which was independent of differences in the test words used.

13.8.iv. The effects of sound-spelling consistency

Another limitation of the experiments presented in this thesis is that in examining the effects of consistency on the use of analogy, only one kind of consistency was studied. Experiments 5, 6 and 7 showed that children used information about spelling-sound consistency differently depending on whether the task was one of reading or of spelling. However, as mentioned at the end of Chapters 9 and 10, only spelling-sound consistency (same spelling, different sound e.g. 'speak-steak') was varied. The effects of varying sound-spelling consistency (same sound, different spelling e.g. 'speak-seek') were not examined. Such manipulations of sound-spelling consistency may lead to different results, and should be examined experimentally.

For example, if children were taught to spell pairs of words inconsistent in sound-spelling relations (e.g. 'speak-seek') rather than in spelling-sound relations (e.g. 'speak-steak') when the task was one of spelling, then an effect of consistency on the number of analogies made may be found, as analogies in spelling rely on predicting spelling from sound. An effect of consistency may also be found if children were asked to spell Ambiguous words such as 'make' and 'lake' after learning 'speak-steak'. Both these possibilities need pursuing before it can be claimed that consistency only affects analogies in reading, and has no effect on analogies in spelling.

13.9. Suggestions for future experiments

Having discussed the weaknesses of the studies presented in this thesis, some directions for future research will now be suggested.

13.9.i. The effect of the number of shared letters on analogy

One topic which should be examined in future experiments is the effect of the number of shared letters in words on children's willingness to use analogies in reading and spelling. As the length of the orthographic sequence common to two words increases, the spelling-sound consistency of the words also tends to increase. The supposed inconsistency of English orthography largely operates at the level of single letters (e.g. 'a' in 'cat', 'ate', 'part', etc.) or of double letters (e.g. 'ea' in 'heat', 'steak', 'heart', etc.). Longer letter strings can also be inconsistent (e.g. 'eak' in 'speak-steak'), but this is rarer, and once words have five or six letters in common inconsistency is very rare indeed (e.g. 'rough' in 'rough', 'through', 'brought').

One hypothesis suggested by the experiments presented in this thesis is that children's willingness to use analogies in reading and spelling new words may increase as the number of shared letters in words increases, as long as these shared letters are in the same orthographic sequence. Experiments 2, 3, and 4 all showed that children used the clue words which they were given to read and spell Analogous words (which shared three letters with the clue words in the same orthographic sequence), but not to read and spell Common Letter words (which also had three letters in common with the clue words, but not in sequence). This suggests that the extent to which children recognise and use common letters in words depends not simply

on the number of shared letters, but on whether these shared letters are in the same orthographic sequence. As the number of shared letters in sequence increases, children may well use analogies more frequently, as the overlap between words becomes more striking.

This hypothesis would predict that more analogies should be made from clue words like 'cream' to words like 'bream' and 'dream', where there are four shared letters in sequence, than from clue words like 'beak' to words like 'weak' and 'peak', where there are only three shared letters in sequence. This prediction could be easily tested experimentally by using the same word game used in Experiments 2, 3 and 4. The hypothesis would extend to words of more than one syllable. Children should make more analogies to words with long sequences of shared letters, such as 'mother', 'brother' and 'another', than they do to words with fewer shared letters in sequence, such as 'caper', 'paper' and 'taper'.

13.9.ii. The effect of the position of the shared letters on analogy

A second topic which would repay further investigation is the effect of the position of shared letters in words on the number of analogies made. This is because shared sequences of letters at the beginnings of words are less likely to be pronounced consistently than shared sequences of letters at the ends of words (e.g. 'leap-learn-leant', 'tout-touch-tour' vs. 'leap-heap-reap' or 'tout-shout-clout').

One possible hypothesis is that this variation in pronunciation consistency with the position of common spelling patterns in words may explain the End effect found in the experiments on single words. Children may make more analogies between the ends of words because

common spelling patterns at the ends of words are better predictors of shared sounds than common spelling patterns at the beginnings of words.

This prediction could be tested by comparing the number of analogies made to the same words when the clue words share common sequences of letters at the beginnings or at the ends: that is, testing within rather than across stimuli, as mentioned in section 13.8.iii. of this chapter. For example, the number of analogies made to words like 'leap' and 'tout' when clue words like 'heap' and 'shout' were presented could be compared to the number of analogies made to 'leap' and 'tout' when clue words like 'learn' and 'touch' were presented. According to our hypothesis, more analogies should be made from the former than from the latter. If this were to be the case, then the End effect would be a further indication of the effect of spelling-sound consistency on children's willingness to use analogies to read (and also to spell) new words.

13.9.iii. The development of orthographic knowledge

The finding that the non-readers in Experiments 1, 2, 3 and 9 were also using analogies to read new words provides another starting point for future work. It suggests that children's knowledge about the reading process is quite sophisticated even at this early stage, since they not only recognise when words have orthographic sequences in common, but also use these common sequences to make predictions about common sounds.

The use of orthographic information is very important for the successful development of reading, as visual strategies for reading new words (such as identification by initial letter) will quickly

become inefficient at distinguishing between different words. One way to look at the development of orthographic knowledge would be to do more experiments using mixed letter case, along the lines of Experiment 9. In this experiment the non-readers made analogies between words written in mixed letter case, showing that they were using an orthographic strategy. We need to know how this orthographic knowledge develops, for example by examining when children become able to recognise similarities across words irrespective of letter case, and how this skill links up with skills such as the development of letter-name knowledge and the development of knowledge about individual spelling-sound correspondences.

One hypothesis is that the development of letter-name knowledge may be crucial for the development of orthographic knowledge, since letter names stay the same whatever case they are written in and also wherever they appear in words, whereas individual spelling-sound correspondences differ depending on which words they are part of. For example, the letter 'a' is called 'a' whether it is part of the word 'able', 'ant' or 'Arthur', but its spelling-sound correspondences in these three words differs (/ei/, /ae/, /ar/). Thus letter-name knowledge rather than spelling-sound knowledge may be crucial for the development of orthographic knowledge and the use of analogies in reading and spelling.

This hypothesis could be tested longitudinally, by examining the relationship between the use of analogy and the degree of letter-name knowledge or the degree of letter-sound knowledge at different stages in learning to read and spell. The hypothesis would predict that as a child's letter-name knowledge increased, her use of analogies to read and spell new words would also increase, but that any increase in

knowledge about individual spelling-sound correspondences would not affect the use of analogy.

13.9.iv. Individual differences in the use of analogy

Another area which requires further research is the causes of individual differences in the use of analogies in reading and spelling. One hypothesis already suggested in this thesis was that the degree of a child's skill in early rhyming might later help determine her use of analogies in reading and spelling. However, this hypothesis was only tested cross-sectionally. The proper test of this hypothesis is a longitudinal one.

If rhyming is a precursor of analogy, then a relationship would be expected between rhyming skill measured at time 1 and the use of analogies measured at time 2. If such a correlational relationship could be established longitudinally, it would be consistent with our hypothesis that early rhyming is linked to later reading and spelling skill via the use of analogy, but it would not show that the relationship was a causal one. To demonstrate causality, a training study would be necessary. It would have to be shown that training a child in rhyming improved her use of analogies in reading and spelling, but did not improve other areas of her reading knowledge, such as letter-name knowledge. Whether such specific training effects would be found remains to be seen.

Another prediction made by this hypothesis is that variations in rhyming skill should be closely linked to variations in the use of analogies in reading and spelling. For example, it might be expected that backward readers who were poor at rhyming would not make analogies in reading new words. It might also be expected that

children who were superior at rhyming would make more analogies than children whose rhyming skill was average for their age. This could be tested by matching children whose rhyming skills varied on reading age, and then comparing their use of analogies in reading and spelling. The hypothesis would predict that children at the same reading age would make analogies differently depending on whether they were good or bad at rhyming. If this were found to be the case, then the major cause of individual differences in the use of analogies would be rhyming ability.

13.9.v. The educational implications of analogy: reading and spelling

A final area which deserves further research is that of the educational implications of analogy. This is important both for reading and spelling development, and for the wider implications of an analogy strategy for teaching and learning.

It is clearly important to examine the educational implications of teaching children to use analogies in reading and spelling. As shown in Chapter 1.2, analogy is a very useful strategy to use to read new words, as some words are impossible to read on a letter-by-letter basis, but can be read without difficulty if analogies are used. This means that analogies can even be used to read supposedly 'irregular' words (e.g. 'light', 'fight', 'might'), without each word having to be learned as a unique visual configuration.

One hypothesis is that if children were taught to use analogies to read new words rather than encouraged to sound words out letter-by-letter, strong pedagogic effects would be found. Teaching

children to use analogy may help to overcome many of the problems faced by beginning readers who stick faithfully to a sounding-out strategy. Such children often have no idea how to pronounce words which they can sound out perfectly well, or in sounding out the words may forget which letter sounds are at the beginning of the word by the time that they reach the end of the word. Encouraging children to work on larger spelling units within words may avoid such problems.

This hypothesis could be tested by comparing the reading progress of children taught only by traditional phonics methods, which concentrate on individual letters within words, with the reading progress of children who were taught about larger spelling units within words in the way required for analogy. This would be a difficult study to do as comparisons between different children in different schools are notoriously difficult to control adequately, but a careful comparison of this kind is not impossible to make. The prediction would be that the children taught about larger spelling units would make more progress in reading than those taught only about grapheme-phoneme correspondences. If the effects found were considerable, then there would be a strong case for teaching children to read by using analogies rather than by sounding out new words on a letter-by-letter basis.

13.9.vi. The educational implications of analogy: Broader issues

A final area for future research concerns the role of analogical reasoning in other areas of the educational curriculum. The work presented here has shown that analogy is not a developmentally sophisticated strategy which is only available to children who are already at the formal operational level, especially when analogical reasoning is tied to a specific concrete task such as reading and

spelling rather than examined by performance on multiple choice verbal analogy problems. Study of the potential contribution of analogical reasoning to other areas of teaching and learning is now clearly an important area for future research.

Given that even 5 year old children can make analogies in reading and spelling, it seems plausible to suggest that analogies can also be made by young children in areas such as mathematical development. It could be argued that mathematical learning is largely concerned with knowing when to use mathematical skills in different situations, in other words, recognising when a problem is analogous to another problem which you already know how to solve. For example, knowing how to perform the mechanics of division is not enough to solve problems requiring the sharing out of fixed quantities between different numbers of recipients. It is also necessary to realise that the problems are of a kind analogous to those through which the mechanics of division were acquired.

The work presented here suggests that in situations of applied concrete problem solving, even very young children would be capable of such analogical reasoning. However, this has yet to be demonstrated experimentally, even though it is an unspoken assumption behind much of the literature on teaching young children. This literature assumes that the key to teaching young children is demonstration through concrete examples. For example, sharing out sweets between dolls and playing at shops is assumed to help the development of mathematical skills such as division and subtraction.

One aim of future work must then be to show that such assumptions are justified, and that children will spontaneously make analogies in areas other than reading and spelling development.

However, perhaps more important is the investigation of which kinds of analogies are most helpful pedagogically. If children have a general analogy strategy available, it seems likely that they will use it more in some circumstances than in others, just as their use of analogy in reading varied with spelling-sound consistency. For example, children may find it easier to see the link between division and sharing than between division and repeated subtraction. Thus it may be easier to teach division by analogy to sharing different fixed quantities (e.g. sharing 50p between five children) than to teach division by analogy to repeatedly subtracting the same number from different fixed quantities (e.g. spending 10p five times from 50p). Such questions must await future investigation.

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APPENDIX

Anova on the number of words read correctly in Experiment 3: Groups 2 and 3

	Sum of Sq.	d.f.	Mean Sq.	F	P.
1. Orders (O)	3.94	2	1.97	0.14	n.s.
Reading(RL)	135.89	1	135.89	9.84	0.005
O x RL	46.42	2	23.21	1.68	n.s.
Error	400.34	29	13.80		
2. Meaning (M)	107.49	1	107.49	69.03	0.0001
M x O	2.35	2	1.17	0.76	n.s.
M x RL	24.03	1	24.03	15.43	0.0005
M x O x RL	9.07	2	4.54	2.91	n.s.
Error	45.16	29	1.56		
3. Condition(C)	12.35	2	6.17	3.85	0.05
C x O	0.09	4	0.02	0.01	n.s.
C x RL	4.93	2	2.47	1.54	n.s.
C x O x RL	2.29	4	0.57	0.36	n.s.
Error	93.13	58	1.61		
M x C	2.46	2	1.23	2.04	n.s.
M x C x O	2.41	4	0.60	1.00	n.s.
M x C x RL	0.18	2	0.09	0.15	n.s.
MxCxOxRL	2.43	4	0.61	1.01	n.s.
Error	35.02	58	0.60		
4. Test (T)	188.63	1	188.63	145.54	0.0001
T x O	0.74	2	0.37	0.28	n.s.
T x RL	0.08	1	0.08	0.06	n.s.
T x O x RL	0.04	2	0.02	0.02	n.s.
Error	37.58	29	1.30		
M x T	0.28	1	0.28	0.40	n.s.
M x T x O	1.80	2	0.90	1.28	n.s.
M x T x RL	0.12	1	0.12	0.17	n.s.
MxTxOxRL	3.47	2	1.73	2.46	n.s.
Error	20.47	29	0.71		
C x T	17.76	2	8.88	20.18	0.0001
C x T x O	0.16	4	0.04	0.09	n.s.
C x T x RL	1.08	2	0.54	1.22	n.s.
CxTxOxRL	1.77	4	0.44	1.00	n.s.
Error	25.52	58	0.44		
M x C x T	0.89	2	0.44	1.24	n.s.
MxCxTxO	3.19	4	0.80	2.23	n.s.
MxCxTxRL	0.29	2	0.14	0.40	n.s.
MxCxTxOxRL	0.52	4	0.13	0.37	n.s.
Error	20.76	58	0.36		
5. Wordtype(W)	75.84	2	37.92	31.53	0.0001
W x O	3.69	4	0.92	0.77	n.s.
W x RL	6.33	2	3.16	2.63	n.s.
W x O x RL	3.23	4	0.81	0.67	n.s.
Error	69.75	58	1.20		
M x W	5.65	2	2.82	5.46	0.01
M x W x O	2.68	4	0.67	1.30	n.s.
M x W x RL	0.94	2	0.47	0.91	n.s.
MxWxOxRL	2.33	4	0.58	1.13	n.s.

Error	29.98	58	0.52		
C x W	97.30	4	24.32	15.25	0.0001
C x W x O	10.40	8	1.30	0.81	n.s.
C x W x RL	4.40	4	1.10	0.69	n.s.
CxWxOxRL	5.97	8	0.75	0.47	n.s.
Error	185.09	116	1.60		
M x C x W	3.83	4	0.96	1.06	n.s.
MxCxWxO	8.37	8	1.05	1.15	n.s.
MxCxWxRL	2.24	4	0.56	0.62	n.s.
MxCxWxOxRL	4.78	8	0.60	0.66	n.s.
Error	105.21	116	1.00		
T x W	69.07	2	34.53	63.03	0.0001
T x W x O	7.79	4	1.95	3.55	0.05
T x W x RL	0.19	2	0.09	0.17	n.s.
TxWxOxRL	0.97	4	0.24	0.44	n.s.
Error	31.78	58	0.55		
M x T x W	0.16	2	0.08	0.22	n.s.
MxTxWxO	0.29	4	0.07	0.20	n.s.
MxTxWxRL	0.00	2	0.00	0.00	n.s.
MxTxWxOxRL	1.04	4	0.26	0.72	n.s.
Error	21.00	58	0.36		
C x T x W	49.23	4	12.31	17.91	0.0001
CxTxWxO	3.95	8	0.49	0.72	n.s.
CxTxWxRL	3.16	4	0.79	1.15	n.s.
CxTxWxOxRL	7.96	8	1.00	1.45	n.s.
Error	79.73	116	0.69		
MxCxTxW	7.17	4	1.79	5.26	0.001
MxCxTxWxO	5.67	8	0.71	2.08	0.05
MxCxTxWxRL	0.78	4	0.20	0.57	n.s.
MxCxTxWxOxRL	5.73	8	0.72	2.10	0.05
Error	39.57	116	0.34		

Words used in the Bradley and Bryant oddity test
of rhyming and alliteration

1. First Sound Different

bud	bun	bus	<u>rug</u>
pip	pin	<u>hill</u>	pig
ham	<u>tap</u>	had	hat
peg	pen	<u>well</u>	pet
kid	kick	kiss	<u>fill</u>
lot	<u>mop</u>	lock	log
<u>leap</u>	mean	meal	meat
crack	crab	crag	<u>trap</u>
slim	<u>flip</u>	slick	slip
roof	room	<u>food</u>	root

2. Middle Sound Different

lot	cot	pot	<u>hat</u>
fun	<u>pin</u>	bun	gun
<u>hug</u>	dig	pig	wig
red	fed	<u>lid</u>	bed
wag	rag	bag	<u>leg</u>
fell	<u>doll</u>	well	bell
<u>man</u>	bin	pin	tin
fog	dog	<u>mug</u>	log
feed	need	<u>wood</u>	seed
fish	dish	wish	<u>mash</u>

3. End Sound Different

pin	win	<u>sit</u>	fin
<u>doll</u>	hop	top	pop
bun	<u>hut</u>	gun	sun
map	cap	gap	<u>pal</u>
<u>men</u>	red	bed	fed
wig	fig	<u>pin</u>	dig
weed	peel	<u>need</u>	deed
pack	lack	<u>sad</u>	back
sand	hand	land	<u>bank</u>
sink	<u>mint</u>	pink	wink

Text of the stories used in Experiment 8

1. Hark! and listen

"Hush(Hark)!" said mother one night as she tied up my **hair** ready for bed. "I can **hear** a lark singing. Listen how sweetly it sings, like an angel's **harp**". I got into bed and listened **hard**. It was a **dark** night, and I knew that the **hawk** would be out hunting. I didn't want the little lark to come to any **harm**.

But then I heard our dog **bark** loudly. I knew that he would keep danger away, so I fell asleep listening to the sweet singing.

2. By the pond rail

When I was little, my brother took me to see the big pond. It had an iron bar(rail) all around it to stop children from falling in, and he had to **raise** me up to see over it. Once I was up I could watch the little ducks **sail** by, some with fluffy **tail** feathers, and even some swans in **pairs** swimming slowly up and down.

Afterwards we saw where the swans had **lain** their eggs, and my brother told me how other animals came to **raid** the nests. When we went home we had to **hail** a taxi, because it started to **rain**. So we had a **real** adventure.

3. Have you ever seen a bee hive?

Have you looked(seen) inside a bee hive? Inside lives a **queen** bee and lots of worker bees. The queen bee is very important, because she lays all the eggs for the **nest**. The worker bees fly out to **seek** pollen for honey. The worker bees go inside the flowers, because they **seem** to know that there is no pollen on the **green** stem or near the **seed**. They even **send** messages back to the hive if they find lots of pollen.

So next time you are **keen** to sniff a flower, make sure that a bee isn't hiding there ready to sting your **nose**!

4. The magic coat

Once upon a time there was a magic cape(coat), which made anyone who wore it turn into a prince. It was **coal-black**, and looked very ordinary, as if it **cost** next to nothing. It had been **cast** off and lost, and now lay in an old **boat** moored on a river by the **coast**.

Here it seemed left to **float** undiscovered. But one day a poor boy came in a **cart** to look for somewhere to keep his pet **goat**. He found the **coat** and put it on. Suddenly he became a handsome prince, his cart turned into a **coach**, and his goat became a white horse!

And they lived happily ever after.

Note Words in parentheses replaced the words they follow in the repeated clue stories.

