A COGNITIVE ANALYSIS OF READING, SPELLING AND MEMORY IMPAIRMENTS IN CHILDREN WITH LITERACY DISORDERS

Christopher Holligan

A Thesis Submitted for the Degree of PhD
at the
University of St Andrews

1988

THE UNIVERSITY OF ST. ANDREWS

A COGNITIVE ANALYSIS OF READING, SPELLING AND MEMORY IMPAIRMENTS IN CHILDREN WITH LITERACY DISORDERS

BY

CHRISTOPHER HOLLIGAN, B.A., M.ED.

THESIS SUBMITTED FOR CONSIDERATION FOR THE DEGREE OF PH.D.

SEPTEMBER, 1987

DECLARATIONS

(a) I, Christopher Holligan, hereby certify that this thesis has been composed by myself, that it is a record of my work, and that it has not been accepted in partial or complete fulfilment of any other degree of professional qualification.

Signed: Date: 28.9.87

(b) I was admitted to the Faculty of Science of the University of St. Andrews under Ordinance General No. 12 in October, 1983 and as a candidate for the degree of Ph.D. on October, 1983.

Signed: Date: 28.9.87

(c) I hereby certify that the candidate has fulfilled the conditions of the Resolution and Regulations appropriate to the degree of Ph.D.

Signature of Supervisor: Date: 28.9.87

(d) In submitting this thesis to the University I understand that I am giving permission for it to be made available for use in accordance with the regulations of the University Library for the time being in force, subject to any copyright vested in the work not being affected thereby. I also understand that the title and abstract will be published, and that a copy of the work may be made and supplied to any <u>bona fide</u> library or research worker.

CONTENTS

ACKNOWLEDGEMENTS

I would like to express my deep gratitude to Dr R.S. Johnston for the help, advice and encouragement she has given so generously at every stage during the production of this thesis.

Thanks are also due to the staff and children in primary schools and reading units in Edinburgh, and primary schools in Dundee for their cheerful cooperation during data collection. I am particularly indebted to Miss C. Ross, Adviser in Special Education, Lothian Region for many valuable discussions.

I would also like to thank Justin Dyer without whose practical help this work would never have reached completion.

Finally, I gratefully acknowledge the Medical Research Council which provided financial support in the form of a 3 year research studentship.

ABSTRACT

The 11 experiments reported in this thesis are concerned with 3 main areas of investigation addressing cognitive processes in children with reading and spelling difficulties. These are 4 main experiments which utilise a variety of reading tasks designed to address the nature of the poor reader groups' approach to single word identification. Evidence of intact phonological reading strategies were found on certain reading tasks, but not on others. Thus support was found both for the hypothesis that poor readers can employ a non-lexical strategy effectively, and for the hypothesis that they are impaired at relying upon this strategy. Two experiments explore the poor readers spelling strategies in terms of their phonological demands. Phonemic segmentation difficulties were found and it was argued that such difficulties may be causally related to the spelling retardation. Four experiments also examined the memory codes used by these groups: evidence of normal phonological coding in working memory, but not longer-term recognition memory was found. Finally, 2 case studies were conducted dealing with reading, spelling and orthographic segmentation ability. Both cases were found to exhibit very clear signs of phonological impairments across a wide range of tasks, and were to different extents less capable than controls at orthographic segmentation.

It is concluded that most poor readers suffer from a mild phonological deficit, and that a much smaller proportion have more severe phonological dysfunctions. However, whether such difficulties are detected will partly depend upon the nature of the task used to interrogate the efficiency of the underlying mechanisms.

PREFACE

The aim of the research reported in this thesis was to examine the nature of the cognitive impairments in children with difficulties involving reading and spelling. Literacy disorders in childhood have been examined from a variety of viewpoints, and this has given rise to several bodies of literature all attempting to clarify the nature of these childrens' difficulties in acquiring literacy skills. A major concern of much of the research adopting an information processing approach has been with the causal role of phonological processing, and poor readers/spellers' impairments in certain component phonological processes (see Wagner and Torgesen, 1987 for a review). The purpose of the present study was to explore these childrens' reading, spelling and memory functions in terms of a cognitive analysis using several complementary tasks. Previous research had tended to focus upon just one area of difficulty (e.g. reading) without also examining the memory codes used by the same group of children. It was decided that by adopting this more comprehensive approach not only would the connections between certain areas of cognitive functioning be elucidated, but also that some existing conflicts in the literature could be resolved. In order to explore the correlates of reading/spelling disorders the studies presented in this thesis have employed a reading age (or level) matched design. In this design the retarded group (i.e. the poor readers/spellers) are matched with younger, normal children at the same level of reading or spelling achievement. The traditional design had compared the retarded group with children of the same chronological age, but the problem with this approach was that any of the deficits observed could be the result of a reduced experience with written language on the part of the retarded group, rather than be a cause of the poor reading or spelling ability. Thus the rationale for the reading age design allows one to determine whether the disabled group are either qualitatively normal (i.e. do not differ from the reading or spelling age controls on the variables measured) and therefore merely delayed in their acquisition of literacy skills, or qualitatively different in the nature of their development (see Bradley and Bryant, 1978, 1979; and for a discussion of this design see Backman, Mamen and Ferguson, 1984).

A general introduction to the experimental work described in this thesis is given in the first 4 chapters. Chapter 1 introduces the models of word recognition and reviews the developmental literature dealing with the nature of the reading difficulty afflicting poor readers. In the following chapter studies of adults with acquired disorders of literacy are described as are the very recent attempts to characterise literacy impairments in childhood in terms of these acquired categories of reading and spelling deficits. Chapter 3 examines the literature dealing with spelling difficulties and the connections between phonemic segmentation and reliance upon a particular spelling strategy. In chapter 4 the studies concerned with the memory codes used by poor readers in immediate and longer-term memory are described and their limitations noted.

Chapters 5 to 9 report the experimental investigations conducted in this study. As there are some differences in the theoretical backgrounds upon which the experiments are based making comparisons across the experimental findings less than straightforward, an attempt was made to keep these chapters relatively self-contained. By reference to the relevant introductory chapter and the introduction to the appropriate experimental chapter the reader can gain an understanding of the issues under scrutiny.

Chapter 5 contains a group study of the reading strategies of 8 and 11 year old poor readers by examining their performances on 2 different reading tasks. In chapter 6 the reading strategies of a different sample of 8 year old poor readers are examined in greater depth on a much wider number of reading tasks. In chapter 7 the methodological viewpoint is similar except this time it is adopted in relation to spelling rather than reading. The sample of 8 year old poor readers who are described in chapter 6 also constitute the subjects for the tasks exploring the nature of poor readers' spelling retardation. In chapter 8 an attempt is made to adopt a single-case study approach to 2 girls with serious phonological reading and spelling deficiences and to compare their performances to a group of poor readers/spellers and to the groups' reading/spelling age controls. Finally, in chapter 9 both samples of poor readers are given various tasks designed to interrogate their memory processes. Throughout the experimental chapters all chronological, reading and spelling ages are expressed in years and months, and their standard deviations, where appropriate, are given in months to the second decimal point.

A general discussion and summary of the findings from these chapters is given in chapter 10 and several tentative suggestions are made about further research which would extend the investigations conducted in this thesis.

CHAPTER 1

SECTION 1: SKILLED WORD RECOGNITION IN NORMAL ADULTS

The developmental research concerned with word recognition in children, and deficits in the word recognition skills of children with reading disorders, has relied heavily upon a cognitive model of how fluent adult readers process words. Thus in order to provide the necessary background to the next section of this chapter and the experiments which form the empirical substance of this thesis the relevant aspects of the theoretical models and the experimental literature will be described.

DUAL-ROUTE THEORIES

The dual-route theory of word (and non-word) processing was originally proposed by Coltheart (1978) and developed further by Morton and Patterson (1980) and Parkin (1982, 1984). Dual-route theory postulates the existence of 2 functionally independent methods of word processing: (a) the <u>lexical process</u> (i.e. the "direct visual route") operates by the direct mapping of the visual-orthographic structure of a printed letter string onto its stored lexical representation in the mental lexicon. According to Coltheart (1978) the reader's knowledge is "... embodied in an internal lexicon. Each word the reader knows is represented in this internal lexicon as a lexical entry, where is stored information about the word's meaning, pronunciation and spelling ..." and (b) the non-lexical process which is assumed to translate the visual-orthographic information contained in a printed letter string (i.e. word or non-word) into a phonological code by utilising spelling-to-sound translation rules. The exact nature of these rules has become a subject of controversy: the "standard" dual-route hypothesis (Coltheart, 1978) proposed that this phonemic transcription process operated by means of a set of grapheme-to-phoneme correspondence rules acquired in the course of learning to read. Such rules were based upon Venezky's (1970) "functional spelling units" which were derived by specifying the mapping relations for no more than a maximum of 2 letters at a time. Thus the units used included the vowel, vowel digraph, consonant, and consonant clusters, and these units were then examined further in order to determine their major and minor correspondences. A major correspondence (i.e. the most typical pronunciation) of the vowel digraph EA is /i/ as in the word BEAN and the minor (i.e. less regular) correspondence is /ei/ as in the work BREAK and /e/ as in BREAD. Accepting Venezky's analysis Coltheart (1978) argued that the non-lexical system would be unable to operate successfully on all classes of English words unless recourse was made to stored lexical knowledge. In other words only the class of regular words (i.e. those containing the major correspondence) would be read correctly via the non-lexical route whereas irregular or exception words (i.e. those containing a minor correspondence) would be incorrectly pronounced. Thus he says "... there is no procedure which, applied to all English words, produces a correct parsing of every word into its constituent functional spelling units without any use of lexical knowledge ..." (Coltheart, 1978, p. 156).

This conclusion has given rise to the concept of the "regularity effect" which amounts to the claim that regular words are read more efficiently than irregular words, a difference which is assumed to derive from either the rate at which these types of word can be processed, or in terms of the presence or absence of congruent phonological information (see e.g. Kay and Marcel, 1981; and for reviews Crowder, 1982; McCusker, Hillinger and Bias, 1981). The so-called regularity effect has been employed as an experimental tool in order to examine whether fluent adult readers ever rely upon phonological mediation or pre-lexical phonology in reading words rather than reading via the direct visual route. Some of the representative studies in this area will now be discussed, as will studies which have relied upon a different index of phonological mediation (i.e. the "pseudohomophone effect"), and then an account will be given of the more current "modified" dual route model.

Experimental Studies

Baron and Strawson (1976) found that college students showed a latency advantage in favour of regular words (e.g. pill) when they were required to pronounce lists of regular or irregular words (e.g. pint). Stanovich and Bauer (1978) replicated their regularity effect, but not its magnitude and concluded that a phonological recoding stage may not be crucial in adult reading. Further support for this assessment is the fact that in lexical decision (i.e. words must be discriminated from non-words - see Meyer and Schaneveldt, 1971) several studies have failed to find regularity effects. Coltheart, Besner, Jonasson and Davelaar (1979) did not find that their subjects took longer to make lexical decisions to irregular than to regular words. A later study by Bauer and Stanovich (1980) which also used the lexical decision task confirmed their findings. These conflicts in the literature could be accounted for in several ways: firstly, task-related factors may affect whether irregularities involving spelling-to-sound relationships interfere with the subjects ability to process the 2 types of word (see Shulman and Davison, 1977; Theios and Muise, 1977; Morton, 1981; Forster, 1981 for an account of the differences between naming and lexical decision tasks). And secondly, the criteria used by the authors of these studies to judge whether a word was to be categorised as "regular" or as "irregular" may have differed. Support for the latter possibility takes us on to a consideration of a "modified" dual route model.

Data from studies of patients with acquired reading disorders and from studies of fluent adult readers has brought about several modifications in the "standard" dual-route model. These modifications have centred upon the character of the rules used by the non-lexical procedure, and have involved the addition of higher-order rules to what was previously a system relying upon low-level individual grapheme-to-phoneme correspondence rules. Shallice, Warrington and McCarthy (1983) have argued that the non-lexical process can operate "... on a number of different types of orthographic unit, namely, graphemes, consonant clusters, sub-syllabic units, syllables and morphemes." (p. 127). In a like manner Patterson and Morton (1985) have argued that the correspondence rules deal with both graphemes and word bodies (e.g. vowel + terminal-consonant segments of monosyllables that remain after the initial consonant cluster has been removed). In their own words they claim that

> "The central procedure of the non-lexical routine can be described as a set of mapping rules from orthographic strings to phonological strings. Accordingly we label this the OPC system (Orthographic-to-Phonology Correspondences). There are 2 major senses in which the OPC system differs from and is more complex than Coltheart's (1978) grapheme-to-phoneme system. Firstly, the OPC system deals with 2 different sizes of orthographic unit: <u>graphemes</u> (that is, the letter or letter combinations which correspond to single phonemes)

> and bodies (the vowel-plus-terminal-consonant segments of monosyllables that remain when the initial consonants or consonant clusters are removed). Secondly, while we shall assume for the moment that mappings at the grapheme level are simple one-to-one translations, the mappings for bodies are more complex and will sometimes require one-to-several translations." (p. 10).

Parkin (1982, 1984) has provided data which is consistent with such a "modified" model of the dual-route theory. Parkin (1984) found no regularity effect with words that were irregular in terms of low-level grapheme-to-phoneme correspondence (i.e. the level relied upon by previous researchers) rules, but regular when higher-order rules were used. Thus the word HEALTH would be traditionally regarded as irregular and parsed as follows: H + EA + L + TH; however, it would become regular if parsed H + EALTH. Thus he found that adults relied upon a non-lexical system which could accommodate certain degrees of spelling-to-sound irregularity, and claimed that previous studies (e.g. Coltheart, Besner, Jonasson and Davelaar, 1979) had failed to find effects of spelling-to-sound irregularity because of their reliance upon the more limited definition as given by Venezky (1970). Even the results of Parkin's studies would appear to require re-interpretation since as pointed out by Seidenberg, Waters, Barnes and Tanenhaus (1984) virtually all of the previous research in this area had failed to control adequately for the potent effects of word frequency. Seidenberg et al. did control for word frequency and were only able to find regularity effects in connection with low frequency words. They concluded that skilled reading takes place largely via the direct visual route, and relies very little upon phonological mediation. The results of studies which have examined the involvement of pre-lexical phonology in adult readers in terms of the pseudohomophone effect have arrived at the same conclusion. These studies will now be discussed.

PSEUDOHOMOPHONE EFFECT

According to the dual-route model non-words (e.g. slint) can only be processed through the non-lexical procedure (e.g. Coltheart, 1978; Humphrey and Evett, 1985). Thus the finding of an effect of pseudohomophony would suggest that the non-lexical procedure had been engaged and therefore that skilled adult readers were relying upon phonological mediation. The actual pseudohomophone effect stems from the finding that non-words which sound like real words (e.g. brane) are more difficult to reject in lexical decision than non-words which do not sound like real words (e.g. slint). Several investigators have reported pseudohomophone effects (e.g. Coltheart et al., 1977; Gough and Cosky, 1977; Patterson and Marcel, 1977; Rubenstein, Lewis and Rubenstein, 1971; Barron, 1978; Barry, 1981). It is thought that the effect arises as a result of confusion connected with the pseudohomophonic non-word accessing a lexical entry (e.g. brain) and then a costly spelling re-check process takes place prior to a decision being made. However, the non-words which do not sound like words can be rejected immediately on the basis of the printed information since they do not introduce confusion due to the fact that they do not sound like real words.

However, it seems likely that the so-called pseudohomophone effect may arise from the fact that the pseudohomophones are more visually similar to real words than the non-pseudohomophonic non-words. Taft (1982) and Martin (1982) after controlling rigorously for the degree to which the 2 classes of non-word were visually similar to words were unable to find pseudohomophone effects, and they argued that previous studies had confounded visual similarity with phonological similarity. For example, Taft claimed that the pseudohomophone (e.g. ile) looks more like the word "isle" than the non-word control "ife" does and that by failing to control for this Coltheart et al. (1977) were able to find "pseudohomophone effects". Thus a thorough re-examination of the basis of the pseudohomophone effect suggests that this index of phonological mediation cannot be used to support the view that adults read by the non-lexical as opposed to the lexical route, and so Taft's findings are consistent with the conclusions of Seidenberg et al. (1984) given above.

Before moving on to a discussion of the developmental literature it is necessary for the sake of completeness (and in order to appreciate the rationale of Experiment 7, Task 4) of this thesis) that we consider criticisms of dual-route theory as expressed by advocates of lexical analogy theories of reading.

LEXICAL ANALOGY THEORIES

The main assumption of the dual-route theory, namely that there are independent lexical and non-lexical processes has been subject to criticism from several sources (e.g. Glushko, 1979, 1981; Kay and Marcel, 1981; Marcel, 1980a; Rosson, 1983; Henderson, 1982). Current attempts to model the pronunciation of print have relied heavily upon the data provided by Glushko (1979) in a series of experiment which demonstrated "consistency effects" in both word and non-word pronunciation (see Henderson, 1985 for a review of the issues). These effects have been used as a major source of support for analogical models, and have been instrumental in the modifications made to the dual-route theory (see e.g. Morton and Patterson, 1985). Glushko (1979) postulated the notion of an "orthographic neighborhood" as the key factor in determining how, once the segmentation of the printed letter string had occurred, that letter string receives its pronunciation. He identified 3 classes of word in terms of the orthographic neighborhood concept: (a) consistent words (i.e. those which would be regarded as regular in terms of Venezky (1970), and which have a word body whose pronunciation is invariant in all the words it is found in (e.g. teach) (b) inconsistent words (i.e. the traditional regular word (Venezky, 1970), but which have at least one visual neighbor whose pronunciation differs e.g. the segment "ive" in the word "five"). (c) <u>exception words</u> (i.e. words which are irregular according to Venezky (1970), but which also contain a word body that is pronounced in a regular manner in several other words e.g. the segment "eaf" in the word "deaf").

Contrary to what the standard dual-route model would predict Glushko (1979) showed that inconsistent words took longer to pronounce than consistent words; also that non-words possessing inconsistent word bodies took longer to pronounce than non-words containing consistent word bodies. These results could not be accommodated by standard dual-route theory since the non-lexical process is regarded as operating purely in terms of the regular spelling-to-sound correspondences and would not therefore predict that there should be any latency difference between the consistent and inconsistent items. Thus Glushko's (1979) results suggested that an analogical mechanism was implicated in the pronunciation of these items rather than an abstract rule-based mechanism. Glushko (1979) proposed an "activation-synthesis" unitary model of pronunciation to accommodate his findings, and he claims that,

> "As letter strings are identified, there is a parallel activation of orthographic and phonological knowledge from a number of sources in memory. This knowledge may include the stored pronunciation of the letter string, pronunciation of words that share features with the letter string, and information about the spelling-to-sound correspondences of various sub-parts of the

letter strings. A pronunciation is generated using a procedure for determining how to modify the activated information in order to synthesise the desired articulatory program." (p. 678).

Thus according to Glushko (1979) the pronunciation of letter strings is achieved on the basis of synthesising the information from word and morphemic segments sharing the same orthographic and phonological characteristics. Non-words are not processed in a qualitatively different manner from words since in his model the notion of separate mechanisms for lexical and non-lexical letter strings is rejected.

A more precise description of how such an analogical model may operate has been given by other critics of dual-route theory. According to Kay and Marcel (1981)

> "A printed letter string is segmented in all possible ways (though some segmentations e.g. those yielding morphemes will predominate ...) each segment automatically accesses matching segments in the orthographic lexical input addresses of all words which contain those segments in equivalent positions. This in turn activates the pronunciation of those segments as they occur in each of those words. The only (de facto) difference between words and non-words is that in the case of known words the segmentation equivalent to the whole letter string will already be represented and have a phonological correspondence, but not in the case of non-words. For an orthographic segment with more than one pronunciation (e.g. "-ave"), that pronunciation which occurs in more lexical exemplars will predominate and, in the case of non-words, be produced. In the case of words, the pronunciation produced by the complete letter string will override any competing pronunciations produced by subsegments ... According to this view, analogical reference of segments to the lexicon is the only process undergone in the skilled reader." (p. 401). (See also Marcel, 1980a for a discussion of this model in connection with clinical data.)

Other versions of lexical analogy theory have been proposed which bear a close family resemblance to Glushko's (1979) (for examples of these other accounts see e.g. McClelland and Rumelhart, 1982; Seidenberg, 1985; Seidenberg, Waters, Barnes and Tanenhaus, 1984; Paap, Newsome, McDonald and Schvaneveldt, 1982). However, like the dual-route model even the analogical models have not been free from criticism. Seidenberg et al. (1984) found an important methodological flaw in Glushko's (1979) demonstration of consistent effects (Experiment 3) which involved the repetition of the same spelling pattern which has alternative pronunciations within the same experimental sequence. Thus subjects were required to give different pronunciations to the same segment and this may have produced response biases of the kind described by Meyer and Schvaneveldt (1974). Seidenberg et al. thus reckoned that an experimental artifact was behind Glushko's so-called consistency effects, and indeed demonstrated this by showing that longer pronunciation latencies for inconsistent words were only found when the items with an exceptional pronunciation preceded the inconsistent words in the experimental sequence. However, several weaknesses have been detected in the research conducted by Seidenberg et al. (1984) which leaves open the question of whether in the case of fluent adult readers analogical accounts are to be preferred over dual-route models of reading (see Norris and Brown, 1985; Stanhope and Parkin, 1987; for details of these criticisms and revised analogical accounts of reading).

CONCLUSION

Clearly both accounts of the processes involved in fluent adult reading would appear to have difficulties which can only be resolved by further experimentation and model building. In terms of lexical analogy theory one might expect to find connections between non-word pronunciation deficits and orthographic segmentation skill (see e.g. Funnell, 1983; McCarthy and Warrington, 1986). In chapter 8 of this thesis this possibility is examined in relation to 2 girls who were found to be very poor at naming non-words and to a small group of poor readers whose ability to read non-words was much less impaired. The next section of this chapter will review the literature dealing with reading development and childrens' reading difficulties from the viewpoint of a dual-route model.

SECTION II: UNSKILLED WORD RECOGNITION - STUDIES OF CHILDREN

The dual-route model has been relied upon to elucidate the acquisition of the component processes in the reading of single words, and to explain the nature of childrens' reading difficulties (see e.g. Seymour and Porpodas, 1980; Treiman and Hirsch-Pasek, 1985; Bryant and Impey, 1986).

In order to appreciate the importance of claims that the non-lexical (or phonological) process plays a critical role in normal reading development some background information is essential.

As far as alphabetic scripts are concerned it has been argued that a particular kind of awareness is necessary if reading skills (and spelling skills) are to be acquired without undue difficulty (see Hung and Tzeng, 1981; Russell, 1982; Makita, 1968). Mattingly (1972, 1980) has referred to such awareness as "linguistic awareness", and others (e.g. Lewkowicz, 1980; Rozin and Gleitman, 1977) have referred to it as "phonemic awareness". Essentially phonemic or linguistic awareness involves the ability to reflect upon the sound structure of one's language and to be capable of manipulating it in various ways. For example, the ability to identify the sounds making up a word, or the ability to delete sounds in words and recombine them in particular ways would indicate competence at this meta-linguistic skill. It has been argued that individuals lacking in phonemic awareness will be seriously handicapped in learning to read our alphabetic script since the correspondences between spellings and the sounds these represent will appear arbitrary (see e.g. Liberman, Rubin, Duques and Carlisle, in press). A clear statement of this position is given by Coltheart (1983) - he claims that

> "If for the first stage of learning to read, the learning of rules relating letters or letter groups to the individual sounds (phonemes) of English words is crucial, it will be necessary

> that the child be first capable of analysing spoken words into their constituent phonemes. A child who is poor at such phonological analysis should therefore experience difficulty in learning to read ..." (p. 370).

Rozin, Poritsky and Sotsky (1971) conducted a study involving teaching children, all of whom were non-readers, to read English represented in Chinese logographs. That they were successful suggests that these children's difficulties were connected with their inability to cope with the phonological requirements inherent in learning our alphabetic script. Several studies have found positive associations between phonemic awareness and learning to read. For example, Calfee, Lindamood and Lindamood (1973) found that children who were proficient on the Lindamood Auditory Conceptualisation Test (Lindamood and Lindamood, 1971) also tended to score higher on the Wide Range Achievement Test (1978). Rosner and Simon (1971) using a sound deletion task, found that performance on this task was correlated with performance on the Stanford Achievement Test (1982). Similar results have been reported by other researchers (e.g. Fox and Routh, 1975; Helfgott, 1976; Liberman, 1973; Zifcak, 1981). Bradley and Bryant (1978) found clear signs of phonological impairments in poor readers: in the first task they were required to identify which of 4 words did not share a sound that was common to the other members in the set (e.g. sun, sea, sock, <u>rag</u>). The poor readers were found to be worse than their reading age controls and the authors concluded that their lack of sensitivity to rhyme and alliteration may be a cause of their reading difficulties (see also Bradley and Bryant, 1985).

Direct proof that training in phonemic awareness assists in the acquisition of spelling-to-sound correspondences has been found in an experimental study: Treiman and Baron (1983) taught twenty children who were about to embark upon formal reading instruction to segment and blend triphonemic spoken syllables (e.g. hem, lig, hig, hem). And, to show that this kind of training was specific to the target spelling-to-sound correspondences rather than to a more general awareness that such relationships exist, the same children were made familiar with another set of similar syllables; - but this time they were merely asked to repeat them. Subsequently the children were taught to associate the individual sound segments of the syllables from the 2 separate sets with letters, and asked to "read" the entire syllables in a paired-associate learning task. They found that children were more prone to combine the written syllable segments into syllables on the "reading" task if they had previously received training in segmenting and blending the same spoken syllables.

Several authors have argued that the ability to use a phonological reading strategy is crucial in connection with learning to read. Jorm and Share (1983) argue that this approach allows the child to become an independent reader who is able to "unlock" the meaning of unfamiliar letter strings by decoding them to sounds that he will recognise. Firth (1972) found in support of their position that the ability to name non-words (a test of the efficiency of the phonological strategy) accounted for much of the variance in reading ability among a large group of 6 year olds (see also Hogaboan and Perfetti, 1978; Perfetti and Hogaboan, 1975; Stanovich, 1982, 1985). Other authors (e.g. Boder, 1971, 1973) have found that children with severe reading difficulties have particular difficulty with the phonological strategy, such children have been dubbed "Chinese" readers. In several discursive papers similar claims have been made that the reading impairment in poor readers is characterised as one which involves the non-lexical process (e.g. Jorm, 1979a, b; Snowling, 1983). Clearly, the conclusion to be drawn from this preliminary discussion is that while adult readers typically read via the direct visual route, children, by contrast, rely more heavily upon the indirect non-lexical route during the course of normal literacy development.

Developmental Studies

Edfeldt (1960) conjectured that children rely upon phonological recoding in their initial encounters with words, and that with experience they switch to visually mediated reading. Doctor and Coltheart (1980) demonstrated that this was actually the case: in their study 6- to 10-year-old normal readers were found to be influenced by phonology in a reading for meaning task which included homophonic words and pseudohomophonic non-words. More errors were made on the meaningless sentences which sounded correct, for example, "He ran threw the street", than on sentences which sounded meaningless, for example, "He ran saw the street". Similar effects were found when the key items were non-words rather than words. Consistent with the idea of a developmental transition in reading strategies the magnitude of the effect diminished with age. They concluded that young children during the early stages of learning to read rely heavily upon phonological encoding, and that this reliance decreases as a result of the increasing influence of visual encoding.

Research involving the reading of single words by children has reached similar conclusions: Waters, Seidenberg and Bruck (1984) in their first experiment examined the effects of irregular spelling-to-sound correspondences using 3 tasks: naming, lexical decision and a sentence acceptability task. The children consisted of 2 groups, able readers and poor readers aged around 8 years. In the naming task both the groups made more errors on high as well as low frequency words. Similar effects were observed in connection with the 2 groups' performance on the lexical decision task. In the sentence acceptability task the children had to decide on the acceptability of sentences containing regular and irregular words; both groups were found to be less accurate in reaching judgements about sentences which contained words which were irregular phonologically. It is interesting that over all the tasks the poor readers showed somewhat larger effects of spelling-to-sound irregularity than the good readers. Thus in this respect they would appear to behave like younger children whose ability to recognise words on a visual basis is less well developed. In their second experiment a group of older (grade 5) children received the same tasks and were found to show a more adult like pattern of performance similar to that reported by Seidenberg, Waters, Barnes and Tanenhaus (1985) discussed above. In other words the older, more skilled readers, can identify a much larger pool of words without interference from irregular spelling-to-sound correspondences.

In a complementary study Backman, Bruck, Hebert and Seidenberg (1984) examined the use of spelling-to-sound information in 3 groups of able readers selected from grades 2-4, and in 2 groups of poor readers from grades 3-4. The authors examined both naming latency and accuracy on various types of word, and on non-words. The stimuli consisted of "regular inconsistent" words (i.e. items with a regular pronunciation (e.g. "gave"), but which share the same spelling pattern as an exception word (e.g. "have"); words with ambiguous spelling patterns is associated with 2 or more alternate pronunciations, each of which is found in several words) (e.g. "clown"); and words with homographic spelling patterns (i.e. words containing the spelling patterns "-ust", "-ane"; these spelling units have different pronunciations in different words); finally regular words (e.g. hope) were also employed.

In the developmental analysis it was found that the younger grade 2/3 children made significantly more errors on exception words (e.g. have), regular inconsistent words, and words containing a spelling pattern which can be read in several ways. By contrast, the older children made a similar number of errors across word classes. The nature of the childrens' pronunciation errors were also examined: errors on exception words revealed a tendency to over-extend the regular pronunciation, and such errors were termed regularisation errors (for example, the word "come" misread as "coam"). The grade 2 children made significantly fewer regularisation responses compared with the older children. The authors concluded that this reflected their weaker knowledge of the regular spelling-to-sound correspondence.

In the analysis comparing the able with the poor readers the poor readers were found to perform very similarly to the younger able readers (i.e. compared with the older able readers they made significantly more errors on exception words, regular inconsistent words and words with ambiguous spelling structures while making a similar number of errors on the regular words). As far as regularisation errors were concerned the poor readers made significantly fewer of these than the able readers.

However, most of these groups' mispronunciation errors were regularisations. As far as non-word naming performance was concerned the poor readers were found to be slower and more error prone than the able readers.

The authors concluded that overall their results strongly supported the view that poor readers recognise words in a qualitatively similar manner to younger children without reading problems, and remarked that the findings "indicate a developmental delay in the poor readers ability to use spelling-sound knowledge. Poor readers in grades 3 and 4 are "poor" because they exhibit performance characteristics of good readers in grade 2, not because they have acquired a radically different decoding strategy" (p. 130).

This conclusion is however not universally accepted, and is at the moment the subject of debate. In the remainder of this chapter the conflicts in the literature regarding the nature of their reading impairment, and whether it is better to characterise it in terms of a developmental delay as opposed to a deficit will be examined.

GROUP STUDIES OF POOR READERS

Evidence Favouring a Phonological Deficit View

A major view is that poor readers suffer from a global phonological dysfunction which is reflected in their performance on tasks involving phonological processing (see e.g. Jorm, 1983; Wagner and Torgesen, 1987). As regards their reading retardation Frith and Snowling (1983) have predicted that they will experience "... problems only in the use of the phonological but not the lexical strategy ..." (p. 331). Such a proposal takes seriously other research examining their phonological skills: for example, there are consistent reports of auditory-verbal deficits rather than visual-perceptual deficits associated with the reading disorder (see e.g. Tallal, 1980; Vellutino, 1979; Bradley and Bryant, 1981; Godfrey, Syrdal-Laksy, Millay and Knox, 1981; Naidoo, 1972; Nelson and Warrington, 1974; Miles, 1974, 1983; Denckla and Rudel, 1976; Montgomery, 1981; and for a review Frith, 1985). This body of research clearly suggests a generalised deficit of a linguistic nature underlies these children's learning deficiencies. Consistent with this idea are reports of strong associations between on the one hand delayed speech development in early childhood, and on the other hand literacy difficulties (e.g. Mason, 1967; Ingram, 1959, 1962, 1970; Ingram, Mason and Blackburn, 1970). Just how such phonological deficiencies interfere with the development of literacy skills will now be fully explored in the context of the experimental studies of these children.

Experimental Studies

Snowing (1980) examined poor readers' ability to decode non-words in a task which did not involve explicit naming. Previous studies have demonstrated that the ability to utilise grapheme-to-phoneme procedures improves with age in normal readers (e.g. Gibson and Levin, 1975; Guthrie and Seifert, 1977). In order to determine whether this was also the case with poor readers she compared their performance with a group of reading age controls. These 2 groups were sub-divided giving 4 groups composed of poor readers and controls whose reading ages extended from 7- to 10-years of age. Using a matching paradigm, they were presented with monosyllabic non-words (e.g. sond) in one modality - either visual or auditory - which had to be recognised in the other modality. A same-different judgement was required regarding whether the second non-word was the same or different (e.g. snod) from the initial non-word. The poor readers were found to be significantly worse than their controls at all levels of reading age. And direct evidence was found for the prediction that non-lexical reading skills remained relatively immature in the poor readers irrespective of an improvement in reading age, since only the children belonging to the control groups with the higher reading ages did significantly better than their fellow controls with lower reading ages. This finding led Snowling to conclude that poor readers

> "... exhibit a selective impairment in the phonological route to reading: an impairment which is analogous to that shown by adult aphasic patients with an acquired dyslexia ... the increase in reading age is therefore most likely due to an increase in sight vocabulary, or reading via a semantic route ..." (p. 304).

In a follow-up investigation Snowling (1981) examined poor readers' ability to deal with the explicit naming of non-words of different complexity. The poor readers and their reading age controls were sub-divided into 2 groups: the "low ability" group and the "high ability" group depending upon reading age. The mean reading age of the children in the lower group was around 8, and those in the higher group had reading ages of about 10 years 6 months. Both poor reader groups were found to be significantly worse than controls at naming bisyllabic non-words (e.g. yomter, slosbon). However, the high ability poor readers were significantly better than the low ability poor reader group. Thus contrary to her previous conclusion this finding indicates that grapheme-to-phoneme skills do, with an increase in reading age, mature in poor readers. The control groups exhibited a similar pattern of performance relative to each other.

Several other studies have reported that poor readers have a specific difficulty with non-words (e.g. Bradley and Bryant, 1981; Di Benedetto, Richardson and Kochnower, 1983; Kochnower, Richardson and Di Benedetto, 1983). In these studies poor readers with chronological ages of around 10 were found to be significantly worse than reading age controls at pronouncing non-words, and these results were taken to reflect an impaired non-lexical procedure. In a large scale investigation Olson, Kliegl, Davidson and Foltz (1984) compared 50 poor readers whose mean chronological age was 15 years 4 months with reading age controls with reading ages of around 10 years 1 month on several tasks. In the "phonological" task - a modified version of a non-word lexical decision task developed by Saffran and Marin (1977) - the children saw 2 non-words presented side-by-side (e.g. caik, dake), and by pressing a button they had to indicate which non-word sounded like a word. In the "orthographic" task, which was designed to assess their visual-perceptual skills rather than their phonological skills, they were asked to distinguish words from non-words which were visually similar and sounded similar (e.g. rain, rane). To perform adequately on this task the authors expected that the children would have to rely upon the visual information.

The poor readers were found to perform worse than controls only on the so-called phonological task, and not on the so-called orthographic task. These findings prompted the authors to conclude that a

> "... deficit in phonological coding seems to be the most distinctive characteristic of the disabled group ... and may be the cause of the most severe deficits in reading ability that are not related to low intelligence or poor education."

Additional evidence for deficient phonological skills in poor readers has been reported by several other researchers employing a variety of reading tasks. Frith and Snowling (1983) administered a non-word naming and regularity task to a group of poor readers aged 10-12 who were compared with reading age controls: all children were asked to read aloud lists consisting of regular words (e.g. spade) and irregular words (e.g. laugh). They were also asked to name lists composed of bisyllabic non-words (e.g. molsmit, slosbon). The poor readers were significantly less accurate than controls at naming the non-words, and they failed to show a regularity effect which was not the case with their controls.

Using the pseudohomophone effect as his index of phonological encoding Barron (1978) compared poor readers aged 10 to 12 with a group of chronological age controls, whose reading age was more advanced. These controls' lexical decision performance showed effects of pseudohomophony in terms of latency and accuracy, whereas the poor readers were only found to be significantly less accurate on the pseudohomophones. Barron concluded that,

> "... the good readers were significantly slower on the pseudohomophones that on the control items suggesting that they used a phonological code in deciding that an item was not a word. Poor readers, however, did not show a reliable pseudohomophone effect suggesting that they did not use a phonological code in making their lexical decisions about non-words ..." (p. 474).

In reaching his verdict however Barron overlooks the fact that the poor readers did exhibit a pseudohomophone effect in terms of accuracy. Thus it was possible that they attempted to maintain decision speed by reducing their level of accuracy. For this reason Barron's study does not provide firm evidence in favour of the view that poor readers experience difficulty in engaging in grapheme-to-phoneme processing. The studies which have failed to discover non-lexical reading impairments in poor readers, and which like Backman et al. (1984) adopt a developmental lag position, will now be reviewed.

Developmental Lag Theory

This theory proposes that poor readers are similar to younger children without literacy problems in being at an earlier stage in their overall linguistic development (see e.g. Critchley, 1968; De Hirsch, 1968; Money, 1966; and for a review of the concept of maturational lag see Satz and Sparrow, 1970).

A study by Beech and Harding (1984) is consistent with this viewpoint. These investigators compared a group of poor readers whose mean chronological age was 9 years 9 months with a group of reading age controls whose mean reading age was around 7 years 2 months, and with a group of chronological age controls. Following a procedure developed by Baron (1979) for controlling for orthographic complexity the children were asked to name regular/irregular words, and non-words generated from them: for instance, the regular word "bone" and the irregular word "done" served as the basis for designing the non-word "yone". They found that their poor readers were not inferior to their reading age controls on these stimuli in terms of latency or errors, but they were worse than their chronological age controls. Their assessment of the poor readers difficulties on these reading tasks, and on several other tasks aimed at examining phonological processing (e.g. the Wepman Test of Auditory Discrimination, 1958; and several speech tests from Pringle, Butler and Davies, 1966) was that,

> "... younger readers were at exactly the same level of immaturity in phonemic processing as the remedial readers, indicating a developmental lag at least within the phonemic processes for the backward readers which is determining their potential level of reading performance ..." (p. 1).

A difficulty with the study by Beech and Harding (1984) concerns the status of their sample of poor readers. According to some standards (e.g. Tizard, 1972; Pavlidis, 1981) they would not be regarded as poor readers in the sense in which the term is used in the present thesis since they were of low socio-economic status. The worry is that their literacy difficulties may be connected not with intrinsic psychological factors, but rather with extrinsic sociological factors. However, a more recent study by Treiman and Hirsh-Pasek (1985), which did employ an appropriate poor reader sample, was able to replicate the findings of Beech and Harding, thus supporting the relevance of their study of this debate. Treiman and Hirsh-Pasek also examined the nature of the pronunciation errors made by the 2 groups as a way of assessing how they approached the reading tasks. The poor readers were not found to differ from their reading age controls in terms of regularisation errors (termed "sound preserving" errors in their study). Previous research, including the study by Backman et al. (1984) discussed already has regarded such errors as reflecting the involvement of the grapheme-to-phoneme mechanism (see e.g. Baron, 1979; Mitterer, 1982; Treiman, 1984; Holmes, 1973, 1978). On other aspects of the error data some group differences did emerge: for instance, the poor readers tended to make more so-called meaning-preserving errors (e.g. the word "says" misread as "say", and "blood" misread as "bleed"). Also, the poor readers made more lexicalisation errors than their controls (i.e. misreading a word or a non-word in terms of a different word see Thompson, 1986). These authors pointed out that both the meaning-preserving errors and the lexicalisation errors were associated with a "Chinese" reading strategy (see Boder, 1973) which is more consistent with the phonological deficit position. However, that the poor readers had proficient non-word naming ability for their reading age argues strongly against such a view, and moreover since the theoretical status of reading errors is itself the subject of debate (e.g. Seymour, 1986) it would appear imprudent to conclude that fundamental group differences in word recognition had been detected.

In a recently published study of 8 and 11 year old poor readers by Johnston, Rugg and Scott (1987a) both the poor readers and their reading age controls were found to rely upon phonological information when making judgements regarding the meaningfulness of sentences in a task originally designed by Doctor and Coltheart (1980). In addition, the poor readers' ability to name non-words was similar to their reading age controls with both groups being superior at naming the pseudohomophonic non-words. Also, in terms of lexicalisation errors to the non-words no group differences were found. These authors concluded that their findings were consistent with the contention of Ellis (1979) that poor readers of average intelligence are appropriately characterised as relying upon a phonological approach. In a similar (unpublished) study of adolescent poor readers by Doctor, Coltheart and Jonasson (1982) the same pattern of results was found since these children performed like the younger good readers in the Doctor and Coltheart (1980) study.

POSSIBLE SOURCES OF CONFLICT IN THE LITERATURE

Task Differences

In the study by Frith and Snowling (1983) their non-words were presented in lists which did not contain any words, whereas in the Treiman and Hirsch-Pasek (1985) study the non-words were presented in the context of words which had served as the basis for the creation of the non-words. For this reason there were close orthographic links between these non-words and the words, which may have encouraged an lexical "analogy" strategy in the children. Indeed recent research has shown that children sometimes make analogies between the spelling patterns in words. Goswami (1986) found that her sample of normal readers aged around 7 years made analogies in reading when given clue words, and that such analogies were more frequently made in terms of the ends of words (see also Baron, 1977, 1979; Marsh, Desberg and Cooper, 1977). With regard to the Treiman and Hirsh-Pasek study it is possible therefore that the poor readers were able to perform as well as their controls on the non-words as a result of their being made aware of lexical orthographic structures while the related non-words were being presented. In other words they may have compensated for deficient non-lexical skills by also relying upon an analogy approach. Indeed Frith and Snowling (1983) explicitly sought to eliminate this possibility by using 2 as opposed to one syllable non-words. It is also noteworthy that Snowling (1981) failed to find significant differences between poor readers and reading age controls in ability to name one-syllable non-words. Thus apart from controlling for the possibility of a lexical analogy strategy being employed it would also appear to be the case that if one wishes to find non-word naming difficulties in some samples of poor readers more complex non-words are necessary. In the case of the study by Johnston, Rugg and Scott (1987a) however, where the poor readers were similar to reading age controls in naming non-words, an account along analogy lines would not explain their findings as their experimental procedures would not have encouraged such an approach in the poor reader group.

Sample Differences

Another possible explanation may be connected with differences in the characteristics of the different samples of poor readers used in the various studies. A rather obvious difference may be related to the extent of the reading retardation; in other words, only the more retarded poor readers might be expected to exhibit impaired non-lexical skills. There is some evidence for this possibility: in the Backman et al. (1984) study the grade 3/4 poor readers were selected if they scored below the 40th percentile on the reading comprehension subtest of the Stanford Diagnostic Reading Test, and none of them had been placed in special classes for the learning disabled. In the Waters et al. (1984) study the poor reader group was said to be "reading at least 5 months below grade level" as determined by the same reading test used by Backman et al. (1984). Comparing such levels of reading retardation with those found in the studies which report clear evidence of impaired non-lexical reading (e.g. Snowling, 1981; Frith and Snowling, 1983) we find that there are differences; for example, the samples used by these authors are generally 2 to 3 years behind in reading and attend special "Dyslexic Clinics", which may even employ some unknown selection procedure effectively preventing poor readers with less severe phonological problems from receiving treatment. Beech and Harding (1984), in a personal communication cited by Johnston, Rugg and Scott (1987a), had "excluded poor readers with very impaired non-word reading" (p. 66). However, although one might not expect to find strong evidence of weak grapheme-phoneme skills in some studies due to the relatively small degree of retardation (see e.g. Waters et al., 1984) this cannot be a satisfactory account since in the study by Treiman and Hirsh-Pasek (1985) the poor readers were some 3 years retarded in reading as well as being identified by a clinic and classified as dyslexic "because their difficulty in learning to read could not be accounted for by poor vision, poor hearing, low IQ, severe educational deprivation, or severe emotional disturbance".

Sub-Groups of Poor Readers

In recent years several authors have suggested that "dyslexia" is not an unitary "syndrome" but rather consists of a collection of homogeneous subtypes (see Ellis, 1985 for a discussion). If there are genuine differences in the types of impairment afflicting poor readers then the possibility arises that the conflicts in the literature already examined may arise from a preponderence of one or other type of poor reader in a particular sample. Such within group differences are generally obscured by the group study methodology and for this reason the issue cannot be resolved unless an alternative, more individually motivated analysis is carried out (see e.g. Seymour and McGregor, 1984). In the next chapter the evidence in favour of there being heterogeneity within the poor reader population will be discussed as will examples of some of the recent approaches used to characterise these individual differences.

C H A P T E R 2

SECTION 1

In recent years there have been several attempts to apply the concepts developed in relation to the cognitive neuropsychology of literacy disorders to developmental reading and spelling disorders. The reading and spelling difficulties of adults with acquired dyslexia/dysgraphia are brought about by cerebral insult, and the term "acquired" is used to designate their literacy problems since prior to becoming neurologically impaired they possessed intact literacy skills. According to Coltheart (1985) the cognitive neuropsychologist attempts to "... demonstrate relationships between, on the one hand, explicit theories of normal cognitive processes and, on the other hand, the patterns of behaviour exhibited by people in whom brain damage has caused impairments of cognitive processes." (p.1). Theoretically motivated studies of adult patients have revealed the existence of a variety of reading impairments which have been defined in terms of components of a modular information processing system (e.g. Shallice, 1981; Patterson, 1981; Coltheart, Patterson and Marshall, 1980).

Several researchers concerned with reading disorders in childhood have argued in favour of the notion that there are developmental equivalents to the acquired disorders of literacy, and that by implication a psycholinguistic case study approach is essential if the existence of such sub-types within the poor reader population is not to be glossed over and their difficulties misrepresented. More generally this body of research claims that we can characterise the nature of developmental reading and spelling problems by reference to the acquired adult reading/spelling syndromes (see e.g. Temple and Marshall, 1983; Coltheart, Masterson, Byng, Prior and Riddich, 1983; Temple, 1986). In this chapter an attempt will be made to review certain types of acquired dyslexia and dysgraphia which have been used as models for case-study approaches into literacy impairments in childhood. Also, examples of the application of this approach to developmental disorders of literacy, and the questions which arise from the entire enterprise will be discussed.

TYPES OF ACQUIRED READING DISORDERS

Acquired Deep Dyslexia

The traditional account of this dyslexia (see e.g. Coltheart, 1980a; Shallice and Warrington, 1980) regards its major features as including the following symptoms: the oral reading of non-words is virtually abolished with the typical error of pronunciation being a lexicalisation (i.e. another word) rather than a neologism (i.e. a non-word) (e.g. Newcombe and Marshall, 1980; Patterson and Marcel, 1977). Also words rated high in imageability are more likely to be read correctly than those rated low in imageability (e.g. Marshall and Newcombe, 1973; Shallice and Warrington, 1975; and for a discussion of imageability see Richardson, 1975a, 1975b). Related to the effect of imageability is the finding of a so-called effect of grammatical word class where more abstract parts of speech (e.g. verbs) are read less easily than more concrete parts of speech (e.g. nouns and adjectives). (See Saffran and Marin, 1977).

As far as errors are concerned the cardinal feature of this syndrome is the semantic error: for example, the word "chair" being misread as the word "table" (see Coltheart, 1980b for a fuller discussion of semantic errors). These patients' phonological difficulties are also reflected in the fact that they do not show regularity effects, and regularisation errors are rare. Similarly, they tend to be insensitive to manipulations of pseudohomophony in the lexical decision task (see e.g. Patterson and Marcel, 1977; Saffran and Marin, 1977). In terms of the dual-route model of reading the deep dyslexic reader approaches the task of reading words (and non-words) by relying upon the lexical route and semantic errors arise because this mode of reading is essentially unstable (see e.g. Newcombe and Marshall, 1980; and for alternative accounts see Shallice and Warrington, 1980; Schwartz, Saffran and Marin, 1980).

Acquired Phonological Dyslexia

The core characteristic of this disorder is the finding that non-word reading is much worse than word reading with the severity of this impairment being somewhat different in individual patients (e.g. Derouesne and Beauvois, 1979; Beauvois and Derouesne, 1979; Shallice and Warrington, 1980; Patterson, 1982; Funnell, 1983). Compared with deep dyslexic patients the non-word naming difficulties are less severe; also some patients are better at reading pseudohomophones than non-words (e.g. Patterson, 1982). With few exceptions (e.g. Funnell, 1983) these patients rarely make semantic errors; several have, like deep dyslexics, difficulties in reading function words in isolation (e.g. Beauvois and Derouesne, 1979; Patterson, 1982) and in text (e.g. Kremin, 1982). In terms of the dual route model of reading phonological dyslexia can be regarded as reflecting a deficit in the non-lexical route to pronunciation and to meaning. Thus in this respect it is similar to the account of deep dyslexia given above. There are, however, 2 theoretical explanations for the differences between deep and phonological dyslexia, and in order to appreciate these it is necessary to describe the patient examined by Schwartz, Saffran and Marin (1980). This patient was able to read aloud exception words (i.e. irregular words) which she showed no sign of comprehending. If exception words can be read aloud successfully without access to meaning taking place then this implies that reading by the lexical route does not necessarily involve access to semantic information. And, since exception words cannot be read aloud via the non-lexical route, some other pathway to pronunciation must have been employed by the patient. Thus these authors postulate a third route to accommodate this result which operates via a phonological lexicon independently of semantics (see also Morton and Patterson, 1980).

One possible account of how phonological dyslexia differs from deep dyslexia in terms of this "triple route model" of reading is that in deep dyslexia in addition to an impaired non-lexical route the direct route which by-passes semantics is also damaged as is the semantic system itself (see Shallice and Warrington, 1980).

Another account of how they differ from each other suggests that in deep dyslexia the lexical route to semantics/pronunciation is intact with the damage involving the other 2 routes. In phonological dyslexia the non-lexical route is not totally impaired and these residual phonological skills serve to block semantic errors. In other words the semantic errors in deep dyslexia arise due to this mode of reading being essentially unstable (Newcombe and Marshall, 1980).

Acquired Surface Dyslexia

Traditionally the key feature of surface dyslexia is the finding of strong effects of spelling-to-sound regularity upon oral reading, and the preservation of reasonable to excellent non-word reading (e.g. Shallice, Warrington and McCarthy, 1983; McCarthy and Warrington, 1986). Regularisation errors are often found and neologisms are more common than lexicalisation error responses. Comprehension problems also occur on printed homophones (e.g. sale) with their definition often being in terms of the homophonic partner (i.e. sail). (See Coltheart et al, 1983; Shallice and Warrington, 1980). In terms of the dual route reading model this disorder is seen as arising from an impaired lexical route with oral reading being mediated via the non-lexical procedure, which is itself sometimes also damaged (e.g. Marshall and Newcombe, 1973).

SECTION 2

Developmental Analogues of Acquired Dyslexia

Jorm (1979a,b) has argued that poor readers as a group are to be compared with deep dyslexics rather than surface dyslexics mainly on the grounds that they both experience difficulties with non-words, and exhibit effects of imageability (Jorm, 1977). According to Jorm both these symptoms are sufficient to justify the comparison with deep dyslexia. Jorm is unperturbed by the fact that semantic errors of the sort found in connection with deep dyslexia are uncommon claiming that "... the dyslexic child has some ability to apply grapheme-to-phomeme rules ... and this rudimentary ability is sufficient to rule out any pure semantic errors ...". Others (e.g. Ellis, 1979) reject the validity of Jorm's position and instead argue in favour of comparisons between groups of poor readers and surface dyslexia. In support of his view he cites the research of Holmes (1973, 1978), where the reading errors made by dyslexic teenage boys resembled those made by surface dyslexics. Thus, rather than suffering from a damaged (or undeveloped) non-lexical procedure, Ellis suggests that these childrens' difficulties arise from deficient lexical route mechanisms.

In a series of experiments Baddeley, Ellis, Miles and Lewis (1982) aimed to examine which of these rival accounts was the more appropriate. In their first experiment they compared 15 dyslexic boys, whose mean chronological age was 12 years 10 months and whose mean reading age was 10 years 3 months with a chronological age control group on lexical decisions to pseudohomophones and non-words. Both of these groups were found to exhibit pseudohomophone effects in both latencies and errors. In their second experiment, the same group of dyslexic boys was compared with a reading age as well as a chronological age control group on non-word pronunciation. Although the subjects in the dyslexic group were able to name the items they performed at an inferior level compared with the 2 control groups in terms of both latencies and errors. A further experiment examined the effects of imageability on reading performance: they found that both the dyslexic group and their reading age controls showed effects of imageability. That both groups were found to be sensitive to imageability led them to conclude that the effect may arise from the age at which words are acquired by children, rather than be a symptom of a phonological deficit.

These authors regarded their findings as broadly confirmatory of the view advanced by Ellis (1979) rather than by Jorm (1979a,b) regarding the locus of the reading impairment. Snowling (1983), however, in a discussion paper dealing in particular with the studies conducted by Baddeley et al (1982), has objected to their conclusions on several grounds. For example, in their first experiment a reading age control group was not employed, making it difficult to determine whether, given their level of reading development, the dyslexics performed normally or abnormally. Snowling also objected to the findings from the lexical decision task on the grounds that the pseudohomophone effect may have arisen from the pseudohomophonic non-words being more visually similar to words compared with the ordinary non-words (cf. Taft, 1982). Furthermore she argued that, given their reading age together with their experience of phonic tuition, the stimuli employed were too simple for any non-word processing deficiencies to be observed among the dyslexics. When the difficulty of the task was increased by asking them to name non-words then their weak phonological skills were detected as they were found to be worse than their reading age controls. For these reasons Snowling rejected the view of Ellis that such children are best characterised by reference to acquired surface dyslexia.

Clearly both these views about the most suitable characterisation of developmental dyslexia (termed "poor readers" in this thesis) assume that it is a unitary condition. However, if this is not the case then it may be possible that both views are able to offer correct classifications of particular sub-populations of poor readers. Evidence for the existence of sub-types of poor readers in group studies will now be examined as will reports of individuals thought to be developmental equivalents to adult patients.

Group Studies - Evidence for Sub-Types

In a clinical study Boder (1973) found evidence for 2 types of reading impairments in children. She coined the terms "dysphonetic dyslexia" and "dyseidetic dsylexia" to refer to these groups. The child belonging to the former category had severe difficulties in applying phonological reading skills, and was occassionally found to make "semantic" errors (e.g. "laugh" misread as "funny"). By contrast, the dyseidetic child was said to be an "analytic reader" and to read "by ear" via a process of phonetic analysis and synthesis. Such phonological skills meant that he was able to decode words and non-words, whereas the dysphonetic child had to rely upon "whole-word visual gestalts" in his approach to reading. Given Boder's descriptions of these sub-types of poor reader it is tempting to compare the dysphonetic child with a deep dyslexic reader, and the dyseidetic child with a surface dyslexic reader.

Mitterer (1982) examined the reading strategies of a group of twenty-seven 8-year old poor readers. He was able to identify 10 children who relied heavily upon the direct visual reading route whom he called "whole-word" readers. Another proportion of the poor reader group relied mainly upon the phonological reading mechanism whom he labelled "recoding" readers. The reading ages of both these groups was similar and so differences in reading age would not explain such skill preferences. Like surface dyslexics the recoders were much better at reading regular than irregular words. By comparison the whole-worders did not show a regularity effect. The errors made by these 2 groups were also qualitatively different: the recoders tended to make neologistic errors on real words (termed "Conservative" errors by Mitterer), whereas the whole-worders' errors were mainly other visually similar real words (termed "Liberal" errors by Mitterer). Also, on non-words the recoders made relatively few lexicalisation errors which was not the case with the whole-worders who instead read many as real words.

Case Studies of Poor Readers

The main difference between the intensive case studies about to be reviewed, and the group studies reporting sub-groups of poor readers is that the case studies were explicitly concerned with the characterisation of the child's literacy disorder in terms of an acquired literacy disorder. A statement by Marshall (1984) makes this point when he argues that typologies of developmental dyslexia should be formulated in terms of models of skilled (adult) reading. He says:

> "I shall assume ... that the syndrome of developmental dyslexia must be defined over a functional architecture of visible language processing ... the relevant functional architecture is one that correctly characterises the normal, fluent adult reading system." (p. 46).

He also claims that "the point of the single-case studies is to show that "developmental lag" ...can selectively affect one ... functional reading component(s)." (personal communication - January, 1986). For this reason he argues that the discovery of correspondences between developmental, and acquired dyslexia will throw light upon the causes of the developmental disorder, thus,

> "The syndromes of developmental dyslexia will accordingly be interpreted as consequent upon the selective failure of a particular adult component (or components) to develop appropriately, with relatively intact, normal (adult) functioning of the remaining components." (Marshall, 1984).

As noted by Bryant and Impey (1986) his view implies that the reading difficulties of poor readers "are to be traced back to his or her peculiar reading patterns" which are then explained by reference to these putative peculiarities. The single case studies which would seem to do just that will now be reviewed.

Developmental Deep Dyslexia

Johnston (1983), in a study of an 18 year old girl with a reading age of 6 years 2 months, found deep dyslexic symptoms. Her case was virtually incapable of reading simple non-words (e.g. teg), was more accurate at naming words rated high in imageability than those rated low in imageability, showed an effect of grammatical word class, and did not find pseudohomophonic non-words easier to read than ordinary non-words. She was also found to make several errors of a semantic nature: for instance, the word "office" was misread as "occupation", and the word "chair" misread as the word "table". However, such errors only constitued some 3% of her total errors and so it is uncertain whether she represents a genuine developmental equivalent of acquired deep dyslexia, or whether she might be more properly described as a developmental phonological dyslexic.

A study by Siegel (1985) also found deep dyslexic symptoms among some poor readers. Like Johnston's case six of her poor readers were unable to name simple non-words, and the majority of their errors were lexicalisations. These children, whose chronological ages ranged from 7 years to 8 years 9 months, made several semantic type errors (e.g. the word "cat" misread as "kitten"). Siegel also studied the performance of several other groups: there were 2 poor reader groups aged 6 to 8 years, and aged 9 to 14 years who were of a similar reading age to the six poor readers. In addition she also examined a group of able readers with a similar chronological age to the six poor readers, and found that the only children to make semantic errors were the children belonging to the group of six poor readers. Thus she concluded that the "... children who make these deep dyslexic errors represent a small portion of the dyslexic population. However, their pattern of errors is significantly different from beginning readers and other dyslexics." (p. 24). In her view this sub-group of the dyslexic population made semantic errors because they possessed no phonological skills, and appeared "to be using a purely visual route to read." (p. 24).

Developmental Phonological Dyslexia

Temple and Marshall (1983) present the most notable example of a case of a child with developmental phonological dyslexia. Adults with acquired phonological dyslexia are regarded as reading mainly by the direct visual route to word recognition and therefore show no regularity effect. Deficient phonological reading skills are also reflected in their poor performance on non-words. The case examined by Temple and Marshall was a 17 year old girl (H.M.) with a reading age of around 10 or 11. Her reading of regular words was not superior to her reading of irregular words and her reading of very simple non-words was very weak. Most of her errors on these non-words were lexicalisations: for instance, "gok" read as "joke", "bix" read as "back" which suggests she attempted to read such items as real words using what Ellis (1984) refers to as a "strategy of approximate visual access" (p. 117). She was not found to make any semantic type errors.

Developmental Surface Dyslexia

Coltheart, Masterson, Byng, Prior and Riddoch (1983) described the case of a 15 year old girl (C.D.) with a reading age of around 10. Acquired surface dyslexics read predominantly via the phonological strategy using the pronunciation of a word to arrive at its meaning rather than its visual appearance. Their heavy reliance upon grapheme-to-phoneme skills results in errors such as the word "island" being mispronounced as "izland", and regularising the word "bread" to "breed" (see Holmes, 1973; Marshall and Newcombe, 1973). C.D. tended to define words in terms of how they sounded, and was better at naming regular words than irregular words. She also made several regularisation errors on the irregular words. However, she was very poor at naming non-words, a deficit which the authors did not try to account for, but which is inconsistent with the idea that her non-lexical skills are largely unimpaired.

Clearly the case studies of Coltheart et al (1983) and Temple and Marshall (1983) present compelling evidence in support of the notion of there being reading difficulties in childhood which can be accounted for in terms of a disturbance to a particular reading mechanism in the way advocated by Marshall above. Before attempting to give a summary of these various studies and their implications a review of similar attempts to discover developmental analogues to adults with a certain form of acquired dysgraphia (i.e. spelling deficit) will be presented. In order to appreciate such reports on children it is first necessary to review the adult literature dealing with acquired spelling disorders. These investigations of pathological spelling have revealed types of spelling deficit which resemble the forms of reading impairments discussed above. It has also been the case that research concerned with this aspect of literacy has generally relied upon a dual route model of spelling (see Ellis, 1982; Shallice, 1981) when attempting to interprete the spelling problem.

TYPES OF ACQUIRED SPELLING DISORDERS

Acquired Deep Dysgraphia

Adult patients suffering from this disorder are typically incapable of spelling non-words, and their attempts at spelling words often result in errors which are non-phonetic approximations of the target word (e.g. "circle" as "cicle"). They are also prone to making semantic errors (e.g. spelling "frighten" as "afraid"). In addition they exhibit imageability effects in spelling and grammatical word class effects (see e.g. Bub and Kertesz, 1982; Nolan and Caramazza, 1983). The performance of such patients has been regarded as reflecting reliance upon the lexical spelling routine with the non-lexical procedure being severely impaired.

Acquired Phonological Dysgraphia

The cardinal feature of this syndrome is better word than non-word spelling ability. As in deep dysgraphia spelling errors tend to be non-phonetic, and words possessing regular phoneme-to-grapheme relationships are not spelt more accurately than words whose relations are irregular in this respect. These patients do not make semantic errors, and the severity of the phonological impairment varies from patient to patient. The fact that these patients find non-word spelling difficult is the key evidence for the view that they suffer from damage to the non-lexical spelling process (see Shallice, 1981; Roeltgen, Sevush and Heilman, 1983; Roeltgen and Heilman, 1984).

Acquired Surface Dysgraphia

Patients with surface dysgraphia rely heavily upon the phonological (or non-lexical) spelling strategy. A core feature being the finding that non-word spelling ability is almost as efficient as word spelling ability. Also, spelling regularity effects are found, with words whose phoneme-to-grapheme relations are predictable being spelt more accurately compared with those whose relationships are unpredictable (i.e. irregular). Their dependence upon phonological skills is also shown in their spelling errors which are generally phonologically accurate (e.g. laugh misspelt as "laf"). (See e.g. Hatfield and Patterson, 1983; Roeltgen and Heilman, 1984; Hatfield, 1982; Beauvois and Derouesne, 1981).

Case Studies of Poor Spellers

To date there has been only one attempt to compare the spelling difficulties of dyslexic children with cases of acquired dysgraphia using the psycholinguistic methodology. Temple (1986) examined the performance of 2 poor readers one of whom (R.B.) is a developmental surface dyslexic, and the other (A.H.) is a developmental phonological dyslexic. In a previous paper (Temple, 1984a) she described their reading performances.

Both children had spelling ages of around 7 years 5 months, and chronological ages of about 10. R.B., a girl, exhibited signs of surface dysgraphia whereas the other child, A.H., a boy, showed symptoms of phonological dysgraphia. R.B. made mainly phonologically accurate spelling errors compared with A.H. Also, only R.B. showed a spelling regularity effect.

However, A.H. was not found to be worse than R.B. in terms of non-word spelling ability which suggests the presence of a confounding deficit in the case of A.H. If his phonological skills were less intact than those of R.B. one would have expected him to be inferior to her at processing non-words. However, on several other phonological tasks these skills were found to be weaker in A.H.: on 2 tasks involving sensitivity to rhyme R.B. was consistently superior to A.H. For instance, given a spoken word stimulus R.B. was able to supply more words which rhymed with it (cf. Bradley and Bryant, 1978, exp. 2) than A.H. Also, at oral rhyme judgement, that is deciding whether 2 spoken words rhyme or do not rhyme, R.B. was better than A.H. Temple concluded on the basis of their overall performance that A.H. was relying upon an abnormal spelling strategy given his spelling age. She was able to reach this assessment in her study because she also examined a group of younger normal children with similar spelling ages to the 2 cases. Like R.B. these children made mostly phonologically accurate spelling errors, and on the basis of this data A.H.'S performance was judged to be qualitatively abnormal.

Conclusion

The question arises as to how valuable these case studies both of reading and spelling impairments are, and what limitations (if any) do they possess? Firstly, as approaches to identifying varieties of literacy impairment in children they are clearly more informative, since compared with other attempts to delineate subtypes of reading and spelling disability in childhood (e.g. Mattis, French and Rapin, 1975) where typology is based upon the associated symptomatology, the above studies specify in detail the nature of the literacy disorder (see Singleton, 1987). One issue which does concern some researchers is the question of representativeness; thus according to Johnston (1983) "The few cases reported may not be typical of developmental dyslexics in general, and their problems may be due to brain damage". A similar claim is made by Jorm (1979a) who adds that "By using a case study approach we are in danger of being misled by the idiosyncracies of the particular case we are studying ...". Other researchers however are unconvinced that such difficulties are sufficient to render the case study approach worthless. For example, Temple (1985) argues that the question of incidence may be irrelevant in certain situations, and claims "Dependent on the question at issue, incidence may or may not be of interest. Even if H.M. (Temple and Marshall, 1983) was the only developmental phonological dyslexic in the world, she would still show that reading can be acquired with only partial phonological skills," though she adds that "it is probable that developmental phonological dyslexia accounts for a substantial proportion of children with developmental dyslexia." (pp. 525-526).

In addition to this issue there is the question of whether a structural model of skilled reading is appropriate to address the developmental context within which childhood literacy disorders arise. Several researchers (e.g. Frith, 1985; Snowling, 1983) question the entire enterprise of trying to delineate the causes of reading difficulties in children by applying what Ellis (1985) refers to as a "preformist programme" (see Marshall, 1984) where children are regarded as being in some sense genetically endowed with a set of reading mechanisms. Frith argues that by relying upon a structural model we ignore the question of acquisition together with the attendant interaction between constitutional and environmental factors. According to Frith developmental dyslexia should be described in terms of arrest at a particular point in the developmental sequence where variations in children's literacy difficulties would be largely explained in terms of compensatory strategies adopted subsequent to the point of arrest.

Since a fully developed developmental theory of reading acquisition is as yet unavailable Snowling (1983) argues that until it is we should continue to "carry out group studies with developmental dyslexics utilising appropriate developmental controls.". Such controls are essential if we are to identify genuine subtypes of poor reader, she argues, since for this to be achieved the children must differ from other poor readers of a similar reading age, and also from normal children of the same reading age. She is also highly critical of the value of the rationale given to justify comparisons of individual dyslexic children with forms of acquired dyslexia adding that "... if an acquired dyslexia can be found in developmental form then, first, it will strengthen the evidence for the independence of certain functional subsystems underlying reading and second, it will show that these subsystems can operate in isolation either because other subsystems have been rendered inoperative through brain damage or else because they have failed to develop. While these questions are undoubtedly of theoretical interest, the answers are unlikely to further our understanding of either the etiology or prognosis of developmental dyslexia ..." (p. 116).

Bryant and Impey (1986) offer compelling evidence in support of Snowling's view regarding the importance of reading age controls. Starting from Marshall's suggestion (see above) that the nature of the difficulties experienced by poor readers are reflected in their putative abnormal reading profiles Bryant and Impey sought to test this view by examining whether similar reading behaviours could also be found in normal children whose reading age was similar to the individuals described by Coltheart et al (1983), and Temple and Marshall (1983). By using many of these authors' tasks and the data reported in their 2 investigations Bryant and Impey found that their normal children were very similar in reading styles to both H.M. and C.D. Also, many of the individual differences which existed between the 2 cases were observed in their group (see Treiman, 1984). The only difference which did differentiate the 2 cases from the normal group was a pronounced difficulty in naming non-words on the part of both cases. And leaving aside this particular impairment (which may be a common dyslexic difficulty - see previous chapter) they concluded "... that the patterns reported in the studies by Coltheart et al and by Temple and Marshall ... tell us nothing about the causes of the 2 dyslexics reading problems. The claim that the dyslexic syndromes are "consequent upon the selective failure of an adult component" must be discarded. The same patterns and the same biases are to be found in perfectly normal children and do not hold their reading back ...".

Temple (1986) did use appropriate spelling age controls and found evidence of qualitative differences between one of her dysgraphic children and the control group. She explained A.H.'s difficulties in using a phonological spelling strategy in terms of her deficient phonological skills relative to R.B. and the control group.

R.B.'s "normal" spelling behaviour was explained in terms of a deficiency involving the "word-specific system" (termed the lexical route in this thesis) which meant that the ability to acquire information about orthographic structure was impaired. And, unlike the 7 year old control group, difficulties would arise for R.B. because given a chronological age of 10 he would be expected to cope with material which involved demands beyond his actual level of spelling competence. In the case of A.H. a similar quantitative level of spelling ability was attained by relying more heavily upon the lexical routine. Thus, at least in Temple's study, some evidence has been found for the view that a particular pattern of literacy impairment does reflect something about the possible causes of the difficulty.

Finally there is a more fundamental danger noted by Ellis (1985) which should be borne in mind when drawing developmental-to-acquired comparisons - the point concerns the extent of our understanding of the acquired literacy disorders and what we may be unwarranted in assuming when a label associated with an acquired category of dyslexia/dysgraphia is attached to any particular poor reader: as Ellis correctly observes "New patterns of breakdown are constantly being reported, and old patterns, formerly thought to be unitary, are fractionating. While generalisations from patients to models (and vice-versa) seem secure, the clustering of patients into syndrome categories is a problematic procedure whose usefulness to cognitive neuropsychologists may be coming to an end. Researchers working with developmental dyslexics could do worse than to embrace the detailed case study methodology of cognitive neuropsychology, but they would be ill-advised to start forcing their children into the tentative and shifting set of acquired dyslexic syndrome categories circa the mid-1980s." (p. 37). And, in the same discussion paper, he gives as an example the case of acquired "phonological" dyslexia: although it is defined in terms of very impaired non-word reading the ability to read such items may depend upon several skills any one of which may give rise to the naming difficulty. Thus according to Ellis "... an adequate account of non-word reading is likely to have to posit at least 3 processes - visual segmentation of a letter string into letter groups ..., mapping of letter groups onto phonemes, and "blending" of phonemes into fluent responses ... Thus we can reasonably anticipate the ultimate recognition of at least 3 subtypes of acquired "phonological" dyslexia ... in the visual segmentation subtype we are likely to find ourselves dubbing as "phonological" dyslexics individuals who have no impairment to any of the cognitive processes which manipulate phonological representations!". Clearly these remarks suggest caution in assuming that we have identified the same impairment when we allocate a particular individual, child or adult, to an acquired dyslexic/dysgraphic category.

The research reported in chapter 8 of this thesis attempts to overcome some of the difficulties associated with a case study approach, and to address certain issues which the research up until now has failed to examine directly.

C H A P T E R 3

SPELLING MECHANISMS AND THEIR RELATIONSHIP TO PHONEME SEGMENTATION ABILITY

This chapter will provide a review of research which examines the spelling difficulties exhibited by children, and the approaches which have been employed to characterise their problems. The focus of the review will be upon group studies of children and their dysfunctions as reflected in the quality of their spelling errors. Many researchers assume that spelling errors can provide information about the cognitive mechanisms which are utilised in attempting to spell words (see e.g. Spache, 1940; Gentry, 1981; Frith, 1980; Wing and Baddeley, 1980). Research into adult patients with neuropsychological impairments have found associations between a tendency to make phonetically inaccurate errors (e.g. "laugh" mis-spelt as "lug") and left temporal dysfunction (e.g. Kinsbourne and Warrington, 1964; Luria, 1973; Reitan, 1955, 1966). As regards the mis-spellings of dyslexic children it is clearly of interest that several authors have found evidence of qualitative differences between their errors and those of normal children (e.g. Kinsbourne and Warrington, 1963; Zangwill and Blakemore, 1972). In her attempts to characterise subtypes of literacy disorders in childhood Boder (1973) has sought to pinpoint their difficulties via a classificatory analysis of their spelling errors.

In recent years the application of explicit cognitive models of the spelling process has brought with it an increase in our understanding of the spelling difficulties experienced by certain groups of children. Using this approach researchers try to trace types of error to defects in one or more of the component processes supporting proficient spelling (see e.g. Barron, 1980; Seymour and Porpodas, 1980; Nelson, 1980; and for a fuller discussion of the model of spelling Ellis, 1982, 1985). An explicit statement of the dual route account of spelling, which is endorsed by many researchers, is given by Nelson:

> "... just as in reading, there are 2 routes of spelling, namely a phonemic-grahemic route which operates by translating the phonemic elements of a word as spoken to their graphemic equivalents and a direct semantic-graphemic route ... the phonemic route for spelling would proceed via the spoken word by analysing this into its constituent phonemic elements and then converting them into their appropriate graphemic equivalents ..." (p. 490).

Using this framework we can trace phonetically inaccurate errors to a deficiency involving some aspect of the "phonemic route" (hereafter termed the non-lexical or phonological spelling strategy/process). One would also expect a regularity effect in spelling if the individual were relying upon some form of phoneme-to-grapheme rule system. On the other hand a dependence upon the lexical process would not give rise to spelling regularity effects, and may result in non-phonetic spelling errors. Thus, given that we can interpret spelling errors by reference to a model, it would appear justifiable to employ an approach which is based upon an explicit analysis of spelling errors as a means of characterising spelling backwardness. The reports in the literature which have (often implicitly) followed this kind of methodology have yielded conflicting conclusions regarding spelling errors as a research tool. These studies will now be examined and suggestions made as to why such inconsistent findings may have arisen. Finally an approach which uses spelling error analysis, but which avoids many of the pitfalls inherent in previous studies, will be outlined and adopted in chapter 7 of this thesis.

In Boder's (1973) study a dual route spelling model is used implicitly: she classifies the strategies underlying spelling in terms of the nature of spelling errors. According to Boder such errors show that the "dyslexic child reads and spells differently from the normal reader"; her so-called dysphonetic child is regarded as experiencing severe problems in employing the phonological strategy, and instead relies upon a visual memory (i.e. lexical process) of the word. A large proportion of this child's errors are phonetically inaccurate (e.g. "scrambled" - "sleber"). By contrast, a dyseidetic child depends upon the phonological route, and so his errors tend to represent the sound of the word accurately (e.g. "laugh" - "laf"). Boder's position is that a deficit in phonological skills is associated with dysphonetic dyslexia/dysgraphia, whereas a deficit involving memory for word-specific information underlies dyseidetic dyslexia/dysgraphia.

Nelson and Warrington (1974), in a large-scale clinical investigation, examined the literacy disorders of children aged around 11-12. A number of these children were found to be significantly worse at spelling than at reading while other children were retarded to a similar extent in both reading as well as spelling. Using the first 10 errors made by all these children on the Schonell test of spelling these authors wished to ascertain whether the two groups would be found to differ in terms of the phonetic accuracy of their errors. After applying their error scheme, which utilised a total of 6 error classes, they found that the "spelling only" retardates made significantly fewer phonetically inaccurate errors than the children who were impaired in both reading/spelling to a similar degree. As they had been able to achieve matching across both groups in terms of similar levels of spelling age these error type differences were not obviously a product of the inappropriate matching of groups. According to these authors their results revealed qualitative differences in the cognitive impairments experienced by the children in the two groups. Of further relevance to their conclusion was the finding that in the case of the children belonging to the group with a similar level of reading/spelling retardation their WISC IQ indicated superior Performance over Verbal IQ. Warrington (1967) had found that children showing this discrepancy tended to also have been delayed in speech development. On the basis of

Warrington's data and their own from the WISC these authors concluded that a fundamental linguistic deficit gave rise to the non-lexical spelling disorder as reflected in the non-phonetic mis-spellings. They were considerably less confident about the possible causes of the other group's (i.e. "spelling only" retardation) spelling difficulties although they speculated that it may be connected with problems in using directional codes (see e.g. Orton, 1937; Herman, 1959). Although not discussed by the authors it is also of interest that the digit-span in the group exhibiting the verbal deficit on the WISC was significantly worse than in the spelling only retardation group. Clearly an impaired short-term memory would make it difficult to perform the necessary operations upon orally presented words which are required for spelling by the phonological route (e.g. phonemic segmentation).

Sweeney and Rourke (1978) aimed to determine more directly the linguistic abilities connected with phonetic and non-phonetic spelling errors. In the course of doing this they studied children at 2 chronological age levels: the younger group consisted of 9 year old children and the older group 13 year old children. At both age levels there were 2 groups of retarded spellers, with 8 children in each group. Also, at both chronological age levels there were control groups consisting of normal children. On the basis of their performance upon the WRAT spelling test these authors classified the groups of retarded spellers as being either "phonetically accurate" or as being "phonetically inaccurate" retarded spellers. Those retarded spellers who made more than 60% of non-phonetic errors were regarded as belonging to the latter group. At both age levels the spelling achievements of both experimental groups were similar.

These authors found that the phonetically inaccurate spellers differed from both the phonetically accurate retarded spellers and from controls on several tasks involving language-related processing at the older age levels. For example, on the Sentence Memory Test (Benton, 1965), the Auditory Closure Test (Kass, 1964), the WISC digit-span (backwards) and the Peabody Picture Vocabulary Test (Dunn, 1965) they were found to be consistently inferior. Thus Sweeney and Rourke concluded that the phonetically inaccurate spellers differ from other groups in "... the processing ... of short strings of words and phonemes. This would suggest that one adaptive deficiency which contributes to the relatively low level of language functioning of phonetically inaccurate spellers ... is an impairment in the ability to perform rather basic, straightforward linguistic operations (e.g. comprehension of rather short word strings, syntheses of sounds and sequence reversals)." (p. 221). Evidence of a "phonological deficiency" was also found on one test given to the younger group of phonetically inaccurate spellers. On the arithmetic sub-test of the WISC, which according to the authors involves skill at phonemic analysis, these children were found to be worse than their controls and the other group of retarded spellers.

Their hypothesis that there may be a "visual deficit" underlying the retardation of the phonetically accurate retarded spellers received no support. They speculated that these children may suffer from the same affliction exhibited by patients with lesions to the left parieto-temporal occiptal region of the brain (Luria, 1973). Such patients have difficulty in generating visual images. On the Higgins-Wertman Test of Visual Closure (Higgins and Wertman, 1968), which was administered in order to examine this possibility, they were not found to differ from the other groups. For this reason the nature of their difficulties was not resolved.

Frith (1980) examined the spelling difficulties of children who were able readers but poor spellers, termed "unexpectedly" poor spellers by her. These children were compared with a group of normal children whose chronological age was similar (i.e. around 12 years of age), and children who were impaired in both reading and spelling. The spelling age of the children belonging to the unexpectedly poor speller group was similar to that of the children behind in reading/spelling. Frith found that the spelling errors of her unexpectedly poor spellers were more like their controls in being mainly phonetically accurate, than like the other retarded group whose errors contained significantly more non-phonetic attempts. She accounted for these errors in terms of a dual route model: it was suggested that some of the non-phonetic errors made by the group behind in both reading/spelling may be associated with phonemic segmentation difficulties (e.g. "amount" spelt as "amot", "ground" spelt as "groud") where "the incorrect phoneme was derived from the speech sound" (p. 502). Other workers in this field have argued that such errors betray phonological problems (see e.g. Marcel, 1980b; Cromer, 1980). By contrast, the errors made by her dysgraphic group (i.e. spelling only retardates) were thought to arise from a difficulty in selecting the most appropriate graphemes to represent word spelling, and occurred at a later stage in the non-lexical process after the correct phonemes had been identified.

Thus the findings from the studies reviewed so far in this chapter are consistent with the proposal that research into spelling difficulties can be fruitfully conducted by making use of the information contained in the errors made by these children. There is data however which is incompatible with this assessment and the studies which have reported this data will now be discussed.

Holmes and Peper (1977) compared the performance of a group of 25 dyslexics (i.e. children behind in reading and spelling) to that of normal children in terms of their errors on the WRAT spelling test. In order to classify these errors a 9-category error scheme was adopted with the scoring being carried out on the first 15 errors. These authors were unable to discover any group differences in error tendencies, and concluded that for the purposes of identifying differences in the cognitive processes of the groups spelling errors were of no value.

Goyen and Martin (1977) arrived at similar conclusions in their study which examined the errors made by a group of 93 boys who were without literacy problems aged about 13 years old. The children were asked to spell some 50 words with a total of 10 categories being used to classify their mis-spellings. These results were then subjected to a factor analysis in order to ascertain whether the errors were related to visual or auditory memory functions. It was found that both the phonetic and the non-phonetically accurate errors loaded on the same Verbal-Intellectual factor. Thus the authors concluded that these types of errors do not themselves represent particular dysfunctions in the cognitive processes supporting spelling, and added that "... there does not seem to be any diagnostic value, ... in classifying students according to the phonetic accuracy of their spelling errors".

Before we can draw any firm conclusions as to the possible reasons for this lack of consensus in the literature regarding the value of spelling error analysis one further point must be made regarding the control groups used by many of these researchers. Until relatively recently it was customary to compare the performance of a retarded group with that of another group whose chronological age was similar to the retarded group and who were not afflicted by any literacy difficulties. The drawback of this approach is that it fails to consider the possibility that the retarded group may be found to behave differently as a result of less experience with the skills under study (i.e. spelling or reading), and that this difference rather than a more genuine difference in cognitive processes may contribute to any significant group difference (see Preface to this thesis). For this reason those studies which have failed to employ the appropriate spelling age control group cannot be regarded as offering unambiguous data as regards this issue.

Nelson (1980) did employ spelling age controls in her examination of the errors made by a group of 30 dyslexics with a mean chronological age of around 12 years and mean spelling age of about 7 years 7 months. The first 20 errors made on the authors own spelling test (the W.E.S.T.) supplied the data which was used in the error analysis. A total of 3 categories were used to classify these errors. She failed to find any group differences between her dyslexic group and their spelling age controls in terms of phonetically inaccurate errors, and concluded that given the normality of their errors the dyslexic's difficulties are most appropriately characterised in terms of developmental lag rather than in terms of a developmental deficit.

The question then arises as to why such discrepant findings in the literature exist. These may be associated with several differences between the studies some of which have already been mentioned. For instance, both the error categories, as well as the numbers of these employed by researchers differed: Frith (1980) used only 3 error categories in contrast to the many categories used by Holmes and Peper (1977). The studies have also differed in the manner in which they analysed the spelling errors, with the study by Goyen and Martin (1977) conducting factor analysis within a single group while others made between group comparisons. Sample differences may also help to account for these differences: for example, the clinical sample used by Nelson and Warrington (1974) may have contained dyslexics with more severe literacy difficulties than the samples used by others (e.g. Nelson, 1980). (See Finucci, Isaacs, Whitehouse and Childs, 1983 for more suggestions regarding the possible sources of the conflicting conclusion of the studies reviewed.) In the next section of this chapter an attempt will be made to outline a more satisfactory approach to the examination of spelling impairments in children.

Spelling and Phonemic Segmentation Ability

The approach favoured here is to examine the performance of the same group of dyslexic children in terms of the quality of their mis-spellings, and on another task which is logically related to spelling skill. Evidence exists which shows that spelling and phonemic segmentation skills are very closely associated with each other. For example, Perin (1983) examined phonemic segmentation skill in 3 groups of teenagers and compared it with the types of spelling errors produced by these children. Previous research dealing with reading ability and phonemic segmentation (see chapter one) suggests that able readers, irrespective of spelling ability, would be more proficient than poor readers on tasks requiring phonemic segmentation. However, as Perin correctly points out, while reading and spelling skills are highly correlated (see Horn, 1969) phonological strategies are initially more intimately linked with spelling rather than with reading development (see Frith, 1985; Read, 1975; Bissex, 1980; Bradley and Bryant, 1979). Thus poor spellers who happen to be good readers would be expected to exhibit less skill compared with individuals who are able at reading and spelling on phonemic segmentation tasks. In line with this expectation Perin (1983) found that her dyslexic group, and the group who were poor only at spelling, made more non-phonetic errors than their normal chronological age controls, and were in addition found to exhibit a similar degree of impairment relative to controls on the"Spoonerism" task which involved explicit phonemic segmentation. In this task the names of "pop" artists were pronounced and the children had to transpose the initial segments of both the forename and the surname to form a "Spoonerism": thus Neil Diamond became "Deil Niamond". As predicted the children who were not retarded in spelling were superior on this task, and Perin argued that the phonetically inaccurate errors made by the groups who did not find the task straightforward were connected with their deficiencies at phonemic segmentation. According to Perin "... their difficulty in spelling is related to problems in phonemic segmentation, which may hinder the employment of phoneme-grapheme correspondences rules ..." (p. 133). Barron (1980) has also conjectured that "... A phonological strategy ... may be particularly hard to acquire for children who have difficulty segmenting the sounds making up words in spoken language..." (p. 212).

In terms of the present approach it would have been worthwhile to determine whether the dyslexics examined by Nelson (1980) were representative of other retarded groups who typically have problems in phonemic segmentation. In line with the possibility of a closer involvement of phonological processes in learning to spell one might expect younger 8 year old dyslexics as compared to 11 year old dyslexics to be worse at phonemic segmentation if they were also found to make more non-phonetic errors compared with spelling age controls. In this regard a difficulty may arise for Nelson's study: since her dyslexics were both 12 years old they may have "overcome" their phonological deficiencies. Many dyslexics are taught via multi-sensory phonic methods (see Miles, 1983), and these would be likely to influence the strategies they eventually adopt, especially phonological ones (cf. Snowling, 1983). If the children in Nelson's dyslexic sample had received such tuition this may account for the fact that they failed to make a larger number of non-phonetic errors. Of course this does not mean that they are without phonological deficiencies, but rather that the intrinsic demands made upon the phonological skills which through effort they had acquired, allowed them to cope with the task as well as younger normal children. These possibilities which make the interpretation of the data from Nelson's study problematical are avoided by using the younger dyslexic child. The experiments reported in chapter 7 will examine spelling errors and phonemic segmentation ability in 8 year old dyslexics and younger normal children whose reading and spelling age is similar.

CHAPTER 4

MEMORY CODING

The purpose of this chapter is to offer a critical review of research concerned with the memory codes employed by poor readers. Several studies have found that poor readers typically have shorter immediate memory spans (e.g. Rugel, 1974; Torgesen, 1975, 1978) compared with normal readers of the same chronological age. In attempting to account for their span deficit some researchers have argued that it arises from their difficulties in making use of a phonological code in working memory, and that this would also compromise the efficiency of the reading process (e.g. Shankweiler, Liberman, Mark, Fowler and Fisher, 1979).

The model of working memory proposed by Baddeley and his associates regards short-term memory storage as involving a system whose capacity is limited and which supports ongoing cognitive processing (e.g. Baddeley, 1981; Baddeley and Hitch, 1974; Baddeley and Lieberman, 1980; Baddeley, 1983). Working memory is conceptualised as consisting of several interrelated subsystems: One subsystem, the central executive, is implicated in the operation of control processes connected with the other 2 ("slave") subsystems; the <u>visuospatial scratch pad</u> can be used to store visual or spatial information; the <u>phonological store</u> is used to retain verbal information. Access to this passive phonological store is obligatory in the case of auditorily presented material, and strategic in the case of visually presented information. Thus in the case of reading the information is sent to this store via a mechanism called the articulatory loop which is primed by subvocally articulating the information.

Conrad (1964) demonstrated the utilisation of phonological encoding in working memory by showing that adults experienced a significant decrement in recall in immediate memory tasks when the to-be-remembered items were related to one another phonologically (termed the phonological similarity effect).

Adequate phonological encoding may contribute to the ease with which a child assimilates phonic word recognition skills. Beginning readers in particular must decode unfamiliar words, retain their sounds and then blend them into whole words. Given the limited-capacity structure of working memory it is possible that a child who experiences difficulties associated with reading single words would also have problems in comprehending text (see e.g. Baddeley, 1979, 1982). For this reason it is not surprising that some authors (e.g. Shankweiler et al, 1979; Jorm, 1983) have speculated that deficient phonological encoding may impair the efficiency of both syntactic and word reading processes. Many of the studies which will now be reviewed have sought to answer the question as to whether poor readers rely upon a phonological code in working memory by determining whether they exhibit the phonological similarity effect.

Shankweiler, Liberman, Mark, Fowler and Fisher (1979) examined phonological encoding in 8 year old poor readers and their chronological age controls. Both visual and auditory immediate memory tasks were used to determine whether they recalled phonologically similar items less effectively than phonologically dissimilar sounding letter names. They found that the poor readers exhibited phonological similarity effects of a significantly reduced magnitude compared with their controls. On the basis of these results the authors argued that poor readers differ from good readers in their reliance upon a phonological memory code, and suggested that "... poor readers attempt to hold the items in memory in some non-phonetic form." (p. 537). Mann, Liberman and Shankwiler (1980) replicated their results using sentence-like stimuli in place of letter names arriving at similar conclusions namely that "poor readers' substandard recall of verbal material may be caused by a failure to make effective use of phonetic coding in working memory" (p. 333). Siegel and Linder (1984) confirmed the findings from both studies finding that with both visual and auditory presentation their 7 to 8 year old poor readers failed to show normal phonological similarity effects.

Other investigators, however have been unable to replicate the results from these 3 studies. Johnston

(1982) reported that poor readers aged 9, 12 and 14 exhibited significantly greater recall of phonologically dissimilar than phonologically similar sounding items with auditory presentation. Also, that the magnitude of the phonological similarity effect shown by the poor readers was similar to those shown by both their reading age and chronological age controls. Hall, Wilson, Humphreys, Tinzmann and Bower (1983) were able to demonstrate phonological similarity effects in their 8 year old poor readers (whose educational attainments were average) using visual presentation. The status of these poor readers is problematical however since they did not show inferior memory spans compared with their chronological age controls. Evidence of a reduced memory span is apparent in the study by Shankweiler et al (1979) since their poor readers were significantly worse in terms of their recall of both types of item than their chronological age controls; in addition Rugel (1974) in an examination of the IQ profiles of poor readers found that in most studies they show impaired immediate memory spans. For this reason the poor readers examined by Hall et al (1983) may be unrepresentative of the general population poor readers.

Connected with this point is the failure of all of the studies cited above to take into consideration the poor readers truncated memory spans when designing the trials used to examine phonological similarity effects. In all of these studies the poor readers and their controls were required to recall the same amount of material. Thus as argued by Johnston, Rugg and Scott (1987b) "It seems possible, therefore, that poor readers have shown reduced phonological similarity effects in some studies because the string lengths employed placed more demands on these groups than on controls." (p. 206).

A further difficulty with all those studies of poor readers which have reported reduced phonological similarity effects is their failure to use reading age controls. In order to ascertain whether poor readers are coding abnormally their performance must be found to differ from what would be expected in children without literacy problems who are of a similar reading age. In their study Johnston, Rugg and Scott (1987b) did take into account task difficulty (memory span size) when deciding upon the number of items to include in their experimental trials. As regards their 8 and 11 year old poor reader's memory spans they found that these were significantly smaller than their chronological age controls, but not their reading age controls. And with span size controlled for they found that both their 8 and 11 year old poor reader exhibited phonological similarity effects of a similar magnitude to those shown by their chronological and reading age controls. They concluded that their results fail to "support the contention that poor readers' difficulties in immediate memory tasks are primarily due to a deficiency in the use of phonological coding." (p. 209).

In contrast to this body of research dealing with short-term working memory the studies which have dealt with recognition memory in poor readers have yielded more consistent findings. In the next section of this chapter these studies will be reviewed.

Recognition Memory and Cued-Recall

Mark, Shankweiler, Liberman and Fowler (1977) compared a group of 7 to 8 year old poor readers with chronological age controls on a recognition memory task. All children were asked to read aloud 28 visually presented words (the "target list"), and were subsequently required to identify these items which had been mixed with a further 28 words. This additional set of words constituted the foil list and consisted of 14 words which rhymed with a word occurring in the target list, and another 14 words which did not rhyme with any of the target list words. As the child was presented with the entire set of 56 words (i.e. targets together with all foils) he was asked to pronounce each word saying afterwards "yes" if he thought he had seen it before in the previous list, or "no" if he did not recognise it as having appeared in the target list.

They found that the good readers made significantly more false-positive responses to the rhyming foils than to the non-rhyming foils, whereas the poor readers made about the same number of false-positives to both foil types. Byrne and Shea (1979) replicated their results using auditory presentation, and also found a trend among their 7 to 8 year old poor readers to select foils which were semantically related to the target items, and suggested they were "selecting a meaning based code for storage" (p. 337).

In a more recent study Olson, Davidson, Kliegl and Davies (1984) replicated the results from these studies on their younger 8 year old poor readers, and suggested that this lack of an effect of rhyme on recognition memory performance may be restricted to these younger poor readers. Rack (1985) however used a cued recall recognition memory procedure to examine memory coding and found evidence of differential effects in his older 13 to 14 year old dyslexics. Compared with their reading age controls they exhibited a preference for a visual-orthographic code in memory. The children in his study were initially asked to make rhyme-judgements about pairs of visually presented words (e.g. "farm-calm"), and then shown one member of the pair (the cue) and asked to try to remember the other member (the target). The dyslexic group were found to be significantly better than their reading age controls at remembering targets cued by non-rhyming orthographically similar foils (e.g. "low" cued by "how") than their reading age controls. By contrast, the reading age controls were significantly more accurate than the dyslexics at recalling targets cued by words which rhymed, but did not look like the target word (e.g. "done" cued by "gun").

In an auditory equivalent of this task he found similar group differences in memory coding to the extent that with auditory presentation the dyslexics were significantly superior to their reading age controls at recalling targets which looked like the cue item, but did not rhyme with it. According to Rack the results of his experiments proved that "the dyslexics code the material in an orthographic form" and, since the overall recall levels of the 2 groups were comparable "that dyslexic readers may be able to compensate for their deficiencies in phonological processing by increased use of orthographic codes." (p. 337).

In chapter 9 of this thesis the factors which may account for these differences in the literature examining short-term working memory and longer-term recognition memory will be examined. Also, experiments aimed at resolving the issue concerning the use of phonological codes in working memory will be presented.

CHAPTER 5

READING STRATEGIES IN 8 AND 11 YEAR OLD POOR READERS

The review of the literature which deals with the reading impairments associated with groups of poor readers demonstrated that there is a clear lack of consensus about the most appropriate characterisation for this impairment (see chapter 1, section 2). The aim of the experiments which are described in the present chapter is to re-examine these conflicts in the literature and to determine the reading strategies of two different age groups of poor readers who are also poor spellers. For convenience an outline of the two major views regarding their reading difficulties will now be given again: the phonological deficit position holds that poor readers rely upon the lexical reading routine and that their non-lexical (i.e. grapheme-to-phoneme) procedure is impaired. It is argued that this deficit is clearly apparent when these children are required to read non-words for which phonological reading skills may be mandatory (see Snowling, 1981, 1983). The alternative view is that poor readers tend to over-rely upon a phonological reading strategy at a time when able readers of the same chronological age have progressed to reading by the direct visual route (see Ellis, 1979).

With reference to this controversy it is of interest that Jorm (1981) found that his poor readers were significantly worse than their chronological age controls at reading non-words, but exhibited clear regularity effects (i.e. were better at reading regular than irregular words). The mean chronological age of the poor readers in his investigation was 10 years 2 months, and their reading age was 8 years 2 months. The reading age of their controls was 10 years 6 months. In support of the phonological deficit interpretation of their difficulties the poor readers were significantly less accurate at naming monosyllabic non-words (e.g. chint, trone) than controls. However, the fact that they read only 6/20 irregular words (e.g. tough, blood) compared with 11/20 regular words (e.g. tooth, chair) conflicts with this account and is rather more consistent with the position that they over-rely upon phonology. Thus Jorm's (1981) data are difficult to interpret in terms of a dual-route model since both regularity effects and non-word naming capabilities are understood to reflect the involvement of the same non-lexical reading procedure. Jorm's findings are not unique however, since in an intensive case study of a child with developmental surface dyslexia Coltheart et al (1983) discovered marked non-word reading difficulties in the context of regularity effects (and several other indicators of a phonological reading style). In contrast to the results of both these studies are the findings of Frith and Snowling (1983): these researchers found a clear association between the absence of regularity effects and impaired non-word reading in their group of poor readers.

Also, the poor readers' reading age controls who were significantly more accurate at reading non-words were found to be more accurate at reading regular then irregular words. For this reason it is possible to accommodate Frith and Snowling's results in terms of the dual route model, and to accept as consistent their judgement that their sample of poor readers suffered from a deficient phonological reading system.

It is, however, impossible to draw any firm conclusions about the poor readers examined by Jorm (1981) or by Coltheart et al (1983) since in both studies reading age controls were not employed. Jorm's able readers may have behaved differently from the poor readers due to their greater experience of reading. In the experiments reported in this chapter a reading-age match design was used in an attempt to eliminate the potential confound associated with depending entirely upon age-matched controls. To assess the reading strategies of the two groups of poor readers two reading tasks are given, both of which are designed to examine the use of non-lexical reading skills.

TASKS

Pronunciation of Regular and Irregular Words

The finding that regular words are read more efficiently compared with irregular words has been interpreted as showing the involvement of the phonological reading mechanism of the dual route model (see chapter 1).

Thus evidence of a phonological reading style in the poor reader groups would be the finding that they were better at reading regular than irregular words. And additional support for the position advanced by Ellis (1979) would be the finding that the poor readers were similar to their reading age controls in this respect. If, however, the view of Snowling (1983) is more accurate as an account of their disorder then we would expect the poor readers not to show a regularity effect and their reading age controls to exhibit a regularity effect.

Pronunciation of Non-Words and Words

One might further predict that if the poor readers are suffering from a non-lexical reading impairment then they would be inferior to their reading age controls at naming non-words. Thus in the present task when required to read aloud non-words and visually similar words the poor readers would be expected to be considerably worse at naming the non-words compared with the words. By contrast, one would expect their reading age controls to be as proficient at naming the non-words as the words. Clear support for the position advanced by Ellis (1979) would be the finding that the poor readers were as able as their reading age controls at reading the non-words.

EXPERIMENT 1 (a) - NAMING TASK: REGULAR AND IRREGULAR WORDS

Method

Subjects

11 Year Old Poor Readers:

Twenty poor readers whose mean chronological age was 11 years 8 months were included in this study on the basis that their reading ages were at least 24 months behind their chronological age according to the Word Recognition Test of the British Ability Scales (Elliott, Murray and Pearson, 1977). Their I.Q. was determined on the basis of a "short form" of the WISC-R (Wechsler, 1974): according to Maxwell (1959) the following 4 WISC-R subtests provide relatively pure measures of Verbal and Performance I.Q., and these are Similarities, Vocabulary (Verbal tests) and Object Assembly and Block Design (Performance tests). Their I.Q. on this short-form WISC-R had to be at least 90. Their mean BAS reading age was 8 years 4 months and their mean I.Q. 105.7 (for details of all the childrens' reading ages, chronological ages and I.Q. see Table 1).

These children attended state (i.e. local authority) primary schools in central Edinburgh catchment areas which could loosely be described as being lower middle-class. None of these children were known to suffer from serious emotional difficulties and their first language was English. They attended "Reading Units" established by Lothian Region in order to cater for children with a specific learning difficulty. By attending these Units the children received about 6 hours of tuition in reading and spelling each week. These skills were approached via a combination of phonics and look-and-say type methodologies. The reports on some of these children supplied by The Child Guidance Service indicated that 12 had experienced delayed speech development in early childhood.

Eight Year Old Poor Readers:

Twenty poor readers whose mean chronological age was 8 years 7 months, were selected on the basis that their BAS reading age was at least 12 months behind their chronological age. Their WISC-R short form I.Q. had to be at least 90. Their mean reading age was 7 years 1 month, mean I.Q. 107.8. These children attended the same primary schools as the older poor readers. They did not attend the Reading Units since it was not the policy of the Region to accept children of this age. However, most of them did receive remedial assistance in school which stressed both approaches to learning literacy skills (see Table 1 for details of reading ages, chronological ages and I.Q.).

Control Groups:

There were separate reading age control groups for the 8 and 11 poor reader groups. There was also a separate chronological age control group for the 11 year old poor readers. Due to difficulties in gaining access to the schools it was not possible to select a chronological age control group for the 8 year old poor readers. These groups are described below.

Reading Age Controls for the 8 Year Old Poor Readers

These 20 younger perfectly normal children were from the same primary schools as the poor readers. They were selected by using the same standardised tests of reading and I.Q. as were used in connection with the poor reader groups. Their mean reading age was 7 years 3 months, mean chronological age 7 years 1 month, mean I.Q. 108.5 (see Table 1 for details of their reading ages, chronological ages and I.Q.).

Reading Age Controls for the 11 Year Old Poor Readers

Twenty younger normal readers from the same primary schools were selected by using the same standardised tests of reading and I.Q. as were used above. Their mean chronological age was 8 years 4 months, mean reading age 8 years 6 months, mean I.Q. 106.4 (see Table 1 for details of reading age, chronological ages and I.Q.).

Chronological Age Controls for the 11 Year Old Poor Readers

Twenty children of a similar chronological age as the older poor readers were selected by using the same standardised tests. These children attended the same or similar schools to the poor readers. Their mean reading age was 11 years 8 months, mean chronological age 11 years

6 months, mean I.Q. 105.1 (see Table 1 for details of reading ages, chronological ages and I.Q.).

Materials

The stimuli were 60 monosyllabic words, divided into 4 classes (1) High frequency regular words (2) Low frequency regular words (3) High frequency irregular words (4) Low frequency irregular words. Spelling-to-sound regularity was determined according to the criteria set down by Venezky (1970). Using the grade 3 norms from Carroll, Davies and Richman (1971) the mean word frequencies were as follows: High frequency regular words, mean 324.5 (S.D. 216.6); low frequency regular words, mean 27.6 (S.D. 24.1); high frequency irregular words, mean 329.0 (S.D. 316.2); low frequency irregular words, mean 29.1 (S.D. 24.7). (See Appendix 1 for stimuli.)

An attempt was also made to control for orthographic irregularity. This was achieved by reference to the Table of bigram frequency norms constructed by Mayzner and Tresselt (1965). The mean bigram frequencies for the regular and irregular words were: High frequency regular words 59.0, low frequency regular words 54.0; high frequency irregular words 61.0, low frequency irregular words 50.0. The purpose of controlling for "visual" irregularity was to prevent this being confounded with irregularities involving spelling-to-sound relationships.

Procedure

These stimuli were randomised and presented singly in lower case print on index cards. The children were asked to read these items out loud at their own pace, and the experimenter recorded each child's response.

Results

Accuracy

These data were calculated as the percentage correct within each word class, and then a 4 way repeated measures analysis of variance was carried out (see Table 2 for means and standard deviations of subjects' scores).

There were 2 between subjects factors: Age ("Eight" and "Eleven" year olds these being the chronological ages of the 2 poor reader groups), and Groups (Poor Readers and Reading Age controls). Thus at "Eight" there were 8 year old poor readers and 7 year old reading age controls, and at "Eleven" there were 11 year old poor readers and 8 year old reading age controls. There were 2 within subjects factors: Regularity (Regular and Irregular Words) and Frequency (High and Low Frequency Words).

A number of significant main effects were found; the older poor readers (i.e. the 11 year olds) were significantly more accurate than the younger poor readers (i.e. the 8 year olds), $F\ (1,76) = 13.23$, $p < 0.0005$. Also the reading age controls were significantly more accurate than the poor reader groups $F\ (1,76)$, $p < 0.0001$. Overall, regular words were named more accurately compared with irregular words, $F(1,76) = 181.19$, $p < 0.00001$. In addition high frequency words were read more accurately than low frequency words, $F(1,76) = 216.0$, $p < 0.00001$.

The main effects were modified by several interactions. Regularity and word frequency interacted significantly, $F(1,76) = 28.88$, $p < 0.0001$. Newman Keuls tests showed that there was a significant effect of word frequency on both regular and irregular words. In order to examine this further a Scheffe test was used: this showed that the regularity effect was greater in magnitude on the low frequency words than the high frequency words. Age and frequency also interacted, $F(1,76) = 7.56$, $p < 0.0075$. A Newman Keuls test showed that while the correct naming of low frequency words increased with reading age, there was no improvement with age in the ability to name high frequency words. An interaction was also found between age, groups and regularity, $F(1,76) = 4.89$, $p < 0.03$. A Newman Keuls test showed that poor readers and reading age controls at both age levels, read regular words better than irregular words. However, the younger 8 year old poor readers named both regular and irregular words less accurately than their reading age controls. The older 11 year old poor readers were as able as their reading age controls on both word classes. A Scheffe test was carried out to determine whether the poor readers and their controls at both age levels differed according to the magnitude of the regularity effect. No significant differences were found. A marginally non-significant interaction was found between age, groups, regularity and frequency F (1,76) = 3.59, p < 062. This seemed to be contributed to by the relatively large frequency effect on regular words shown by the 8 year old poor readers.

Summary

Both the 8 and 11 year old poor reader exhibited clear regularity effects (i.e. they were significantly better at reading regular than irregular words). In addition the magnitude of the regularity effect exhibited was similar to that shown by their reading age control groups. A puzzling result was the discovery that the younger poor readers were less accurate at naming regular as well as irregular words compared with their reading age controls.

EXPERIMENT 1 (b): NAMING TASK - NON-WORDS AND WORDS

Method

Subjects

As for the preceding experiment.

Materials

These stimuli were taken from an unpublished list designed by Coltheart (1981b) to diagnose phonological dyslexia. In a case study of children Temple (1984b) had also used them. The stimuli consisted of 25 non-words and the same number of words. The non-words were generated from the words by changing one letter in the word (e.g. from "boy" the non-word "doy" was created). For details of these items see Appendix 2).

Procedure

These stimuli were handwritten in lower-case on index cards, one item to a card. They were randomised and presented to each child one at a time. The children were informed that some of the items were "made up" words, but that they could still be read out loud. They worked through the pack of 50 items at their own pace and the experimenter recorded each child's response.

Results

Accuracy

The statistical analysis was based upon the data supplied by 16 rather than 20 of the reading age controls. The other 4 children who had taken part in the previous experiment were unavailable for participating in this one.

These data were subjected to a three way repeated measures analysis of variance. There were 2 between subject factors: Age ("Eight" and "Eleven" year olds these being the chronological ages of the 2 poor reader groups), and Groups (Poor Readers and Reading Age controls). There was one within subjects factor: Word Type (Non-Words and Words). The unweighted means method was employed to deal with unequal subject numbers. (See Table 3 for results giving means and standard deviations.)

There was no main effect of age, $F(1,68) = 1.04$, N.S. However, there was a main effect of groups, $F(1,68) = 62.69$, $p < 0.0001$; the reading age controls were significantly more accurate overall then the poor readers. There was a significant main effect of Word Type, $F(1,68) = 166.19$, $p < 0.0001$, with more correct responses being made to Words than to Non-Words. However, this main effect was modified by an interaction between groups and Word Type, $F(1,68) = 49.78$, $p < 0.0001$. A Newman Keuls test showed that the poor readers were able to name the Words as well as their reading age controls, but were significantly worse at naming the Non-Words compared with their reading age controls. No significant interaction was detected between age and groups, age and word type, or age, groups and word type, $F < 1$ in all cases.

Summary

The main finding is that the poor readers were significantly worse than their reading age controls at naming non-words, but as good as them at naming words.

General Discussion

Our general concern is this chapter has been to examine the cognitive reading mechanisms responsible for the reading of words, and the reading of non-words with reference to the dispute about the status of poor readers' difficulties. The finding from experiment 1(a) supports the view that poor readers are capable of utilising phonological information in reading words. This conclusion follows from the fact that both the 8 and 11 year old poor readers were significantly more accurate at reading regular than irregular words. One important implication of the fact that they behaved like their reading age controls in this respect is that they would appear to perform as a developmental lag account would predict. There are therefore clear parallels between the results of this experiment and previous experiments by other researchers who have also found evidence of poor readers relying upon a phonological strategy (e.g. Beech and Harding, 1984; Treiman and Hirsh-Pasek, 1985).

A quite different result is however apparent in experiment 1(b) where the poor reader groups were very poor at reading the non-words compared with their reading age controls (see Table 3). If it is the case that non-words are read by grapheme-to-phoneme conversion procedures as the dual route model suggests then it follows that these poor readers suffer from a deficiency involving the non-lexical mechanism. This assessment is in line with the position advanced by some researchers that the problems experienced by poor readers are to be conceptualised as arising from a deficit in the non-lexical route (e.g. Snowling, 1981, 1983). Thus since poor readers can be regarded as positively deficient in this sense it follows that they are qualitatively different from younger normal children of a similar reading age. Indeed since the older poor readers were only found to be marginally superior to the younger poor readers at reading the non-words this clearly implies that non-lexical reading skills do not develop with reading age in these poor readers.

Considered together the findings from both experiments would seem to be incompatible with one another: in other words, the poor readers seemed to be able successfully to adopt a phonological strategy in connection with the regularity task, but not in connection with the non-word naming task. There are at least two possible ways of attempting to reconcile these seemingly contradictory results. First, the ability to use a phonological strategy in naming words (as evidenced by a regularity effect) may differ from the use of this ability to name non-words with respect to the demands made upon the non-lexical routine. One may possess sufficient phonological reading skills to exhibit regularity effects, but not to process non-words to the same degree of efficiency. Therefore the poor readers' phonological skills may have been adequate to cope with the task involving words (i.e. experiment 1(a), but not with the task involving non-words i.e. experiment 1(b)). An alternative way of trying to account for these findings would be to enlarge our conception of the phonological reading route. Thus rather than follow Coltheart's (1978) account of this route where the relationships between spelling and sound designate individual grapheme-to-phoneme associations we may rather consider it along the lines of a "multi-levels" model (e.g. Shallice et al, 1983; McCarthy and Warrington, 1986; Patterson and Morton, 1985). In terms of these more recent conceptions of non-lexical reading, letter strings can be segmented in parallel at several levels of analysis which range from individual graphemes to morphemes and sub-syllabic units. The segmentation processes necessary for the successful reading of non-words may be more complex than those required for supporting competent word reading. An unpublished study by Seymour and May (1981) (cited by Seymour and McGregor, 1984, p. 69) did indeed discover that non-word reading involves more complex visual analytical operations than word reading. If it is in fact true that competent non-word reading involves an awareness of the variety of possible segmentations that can be carried out on the printed letter string then poor readers may have difficulty in detecting the larger orthographic segments. An awareness of these larger units may not be as important in reading words where an ability to detect the more low-level grapheme-to-phoneme relations may suffice. Speculations along these lines would help to explain why their (limited) phonological reading styles could give rise to a combination of regularity effects and impaired non-word reading.

There are other aspects of the present results which also demand attention. Although the 8 year old poor readers did perform like their controls in experiment 1(a) in that both groups showed regularity effects they were also found to be less accurate overall. In this respect they also differ from the second sample of 8 year old poor readers described later in this thesis: see chapter 6. And for this reason the finding may not be replicable and carry no implications for the difficulties experienced in general by 8 year old poor readers. However, it could be argued that this anomalous behaviour on the part of these younger poor readers is indicative of a deficit in visual-spatial perception. The research reviewed by Vellutino (1979) suggests that this is unlikely to be due to a gross perceptual disorder. More recent research has found deficiencies in the visual system of poor readers which are of a more subtle nature (see e.g. DiLollo, Hansom and McIntyre, 1983; Lovegrove, Martin and Slaghuis, 1986). The poor readers in the present study may suffer from subtler forms of visual impairment as was already intimated in connection with their performance on the non-words relative to the words, as well as being worse overall in the regularity task (i.e. the 8 year old poor readers).

The failure of the present study to replicate the results of other researchers (e.g. Beech and Harding, 1984; Treiman and Hirsh-Pasek, 1985) as far as the poor readers' non-word reading is concerned is unclear. Unlike the samples of poor readers used in these other studies the present sample may suffer from a visual as well as phonological impairment (see above). It was suggested earlier in this thesis (see chapter 1) that the mode in which the children in the study by Treiman and Hirsh-Pasek were given the non-words to read may have made the task easier by its elicitation of a "lexical analogy" approach; this may have enabled them to compensate for weak phonological reading skills which were exhibited in aspects of the error data.

In conclusion the findings from these 2 experiments would appear to raise more problems than they resolve. On the basis of the present data it cannot be determined which of the two accounts of the finding involving the poor readers showing regularity effects in conjunction with weak non-word reading is the more appropriate. However, taken at their face value the findings from the regularity tasks are more consistent with the view of Ellis (1979) namely that poor readers over-rely upon phonology, than the view of Snowling (1983) that they do not depend upon a phonological strategy. Similarly, taken at their face value the results from the non-word reading task indicates impaired grapheme-to-phoneme skills in the poor reader groups compared with their controls. Thus this result fits Snowling's (1983) position that these children have a deficit in the phonological reading route, and that a deficit rather than a lag model offers the most appropriate description of their developmental status (see e.g. Bender, 1957; Rourke, 1976; Satz and Sparrow, 1970). In the next chapter an attempt will be made to explore some of these issues in more detail in connection with an entirely new sample of poor readers and reading age controls.

TABLE 1

Mean Chronological Age, Reading Age and I.Q. Level of Each Group

	Chronological Age	Reading Age	I.Q.
Eight year old poor readers:	8.7 (5.22)	7.1 (4.08)	107.8 (10.76)
Reading age controls:	7.1 (3.19)	7.3 (5.18)	108.5 (8.72)
Eleven year old poor readers:	11.8 (10.1)	8.4 (6.85)	105.7 (12.1)
Reading age controls:	8.4 (5.94)	8.6 (5.68)	106.4 (7.54)
Chronological age control:	11.6 (8.0)	11.8 (8.99)	105.1 (9.19)

@ SD in parentheses

TABLE 2

Mean Percentage Correct, Naming Regular and Irregular Words

	Regular Words		Irregular Words	
	high frq	low frq	high frq	low frq
Eight year old poor readers	73.95 (18.88)	54.70 (25.32)	64.40 (21.65)	37.65 (15.66)
Reading age controls	88.40 (10.27)	79.70 (10.27)	77.40 (11.00)	54.35 (13.33)
Eleven year old poor readers	83.85 (13.13)	78.10 (18.50)	76.05 (18.87)	55.00 (19.28)
Reading age controls	90.95 (8.04)	81.10 (9.81)	83.40 (9.34)	66.90 (10.31)

@ SD in parentheses

Note: Chronological controls for 11 year old poor readers at ceiling therefore no data.

TABLE 3

Mean Percentage Correct, Naming Non-Words and Words

	Non-Words	Words
Eight year old poor readers:	48.00 (14.45)	89.40 (7.25)
Reading age controls:	84.62 (8.45)	95.75 (5.16)
Eleven year old poor readers:	52.40 (12.59)	92.60 (9.82)
Reading age controls:	85.25 (5.97)	98.00 (2.92)

@ SD in parentheses

Note: Chronological age controls for 11 year old poor readers at ceiling therefore no data on their performance.

CHAPTER 6

READING STRATEGIES IN 8 YEAR OLD POOR READERS

In the light of our results from the previous 2 experiments it is clear that poor readers are able to employ a phonological reading strategy with success in certain situations, but have difficulty in utilising that strategy in other situations. This rather qualified conclusion follows from the findings of experiments I(a) and I(b) respectively. A disappointing feature of these experiments was connected with the fact that they left certain important issues unresolved. One issue which would appear to merit further investigation concerns the possible link between the competent use of the phonological strategy by the poor readers and the nature of the reading task. Through exploring the poor readers' performance on a wider variety of reading tasks (and types of non-word) one would be in a position to make less speculative conclusions about the characteristics of their reading style. An assessment of how they approach these tasks can also be made by examining the kinds of errors they make (i.e. whether they suggest a "logographic" approach which would give rise to lexicalisation errors, or alternatively whether they attempt to rely upon a phonological reading style which would give rise to neologistic responses).

If, as we have suggested earlier, poor readers' difficulties with non-words are associated with the demands these items make upon segmentation skills then we would expect the poor readers not to be impaired on simpler non-words compared with more complex non-words. This line of reasoning does not exclude the contribution of phonological impairments to their difficulties which may indeed be a major source of their non-word naming problems. Apart from examining these issues the experiments in this chapter also aim to replicate the main features of the 2 previous ones on a different sample of 8 year old poor readers and their reading age controls.

EXPERIMENT 2 NAMING TASK: REGULAR AND IRREGULAR WORDS

Method

Subjects

Eight year old poor readers

Twenty poor readers of mean chronological age 8 years 6 months were selected on the basis that their reading ages were at least one year behind their chronological ages according to the BAS test of reading cited in the previous chapter. Also, their I.Q. (arrived at using the test cited in the previous chapter) had to be at least 90. Their mean reading age was 7 years and mean I.Q. 103.65. These childrens' spelling age was 7 years 4 months. These children attended similar schools to the previous sample and therefore were familiar with the same approach to learning to reading and write.

Reading age controls

Twenty younger normal readers/spellers were selected to serve as reading age controls (in the next chapter these children are also spelling age controls for these poor readers). The same standardised tests as were used previously were used to select them. Their mean chronological age was 7 years 2 months, mean reading age 7 years 2 months, mean spelling age 7 years 4 months and mean I.Q. 107.7. (For details of these groups chronological ages, reading ages, spelling ages and I.Q.'s see Table 4.)

Materials

These were the same as those used in experiment 1(a).

Procedure

This was identical to that used in experiment 1(a).

Results

Accuracy

These data were expressed as the percentage correct within each of the four word categories, and then a 3 way repeated measures analysis of variance was carried out. (See Table 5 for means and standard deviations.)

There was one between subjects factor: groups (poor readers and reading age controls), and there were 2 within subjects factors: regularity (regular and irregular words) and frequency (high and low frequency words).

There was no main effect of groups, $F < 1$. However, more correct responses occurred to regular than to irregular words, $F(1,38) = 67.11$, $p < .0001$. There was an interaction between regularity and frequency, $F(1,38) = 7.31$, $p < .01$. Newman Keuls tests showed all pairwise comparisons to be significant. The interaction was most probably due to a larger frequency effect on irregular than regular words. No other effects were significant, $F < 1$ in all cases.

Pronunciation Errors

Lexicalisations and neologisms

Lexicalisation errors involve the production of a different word from the target word (eg 'SAT' for 'HAT'). Neologisms are errors involving the production of a nonword instead of the target word (eg 'GOK' for 'JOKE'). These errors were explored to acquire extra information about the childrens' reading strategies on the regular/irregular words. These errors may reflect the operation of compensatory strategies which arise as a result of a defect involving one of the 2 reading mechanisms on the dual route model. Lexicalisation errors, for instance, may be due to inefficient phonological reading strategies; by contrast, neologistic errors may be connected with an over-reliance upon the phonological routine. In line with these possibilities are the findings that lexicalisation errors are common in phonological and deep dyslexia, and neologisms tend to be more common in surface dyslexia.

These errors were expressed as a percentage within each of the 4 word categories, and then a 4 way analysis of variance was carried out. (See Table 6 for means and standard deviations.)

There was one between subjects factor: groups (poor readers and reading age controls), and 3 within subjects factors: error type (lexicalisations and neologisms), regularity (regular and irregular words), and frequency (high and low frequency words).

There was a significant main effect of groups, $F(1,38) = 7.96$, $p < .008$, the reading age controls making more errors in these categories overall. There were also a number of 2 way interactions: groups by frequency, $F(1,38) = 4.07$, $p < .05$, groups by error type, $F(1,38) = 4.93$, $p < .04$, and regularity by error type, $F(1,38) = 17.59$, $p < .0002$. A number of 3 way interactions were also found to be significant: groups by frequency by error types, $F(1,38) = 6.9$, $p < .02$, and regularity by frequency by error types, $F(1,38) - 4.29$, $p < .05$. However, all 4 factors were found to interact: groups by regularity by frequency by error type, $F(1,38) = 5.65$, $p < .03$. Newman Keuls tests showed that the poor readers made more lexicalisation errors to high frequency regular words than controls, and fewer neologistic responses. However, on low frequency regular words the poor readers made fewer lexicalisations than controls, and a similar number of neologisms. As far as both high and low frequency irregular words were concerned, the poor readers made fewer neologistic responses than controls, but a similar number of lexicalisations.

Pronunciation Errors

Regularisations

Regularisations are errors involving the inappropriate application of regular spelling-to-sound rules to irregular words (eg 'ISLAND' pronounced as 'IZ-LAND'). These errors are made on irregular words. They constitute a subset of the neologistic errors to irregular words. Theoretically they are regarded as indexing dependence upon a phonological strategy (see Holmes, 1973, 1978; Ellis, 1979) and so are more common in surface dyslexia rather than phonological dyslexia.

They were expressed as a proportion of the errors made on irregular words and a 2 way analysis of variance was carried out. There was one between subjects factor: groups (poor readers and reading age controls), and one within subjects factor: frequency (high and low frequency words). (See Table 7 for the means and standard deviations.)

There was no main effect of groups, $F(1,38) = 2.67$, NS; nor was there a main effect frequency, $F(1,38) = 2.26$, NS. Furthermore, these factors did not interact, $F(1,38) = 1.13$, NS.

Discussion

The results from experiment 2 indicate that both groups exhibit regularity effects, and that the magnitude of these effects do not differ between the groups. Thus the accuracy data provides clear support for the view that poor readers adopted a phonological strategy in this task, and unlike the first sample of 8 year old poor readers (see chapter 5) they were not found to differ from controls in their level of accuracy overall. The finding that both groups were not statistically different in terms of regularisation errors is also consistent with these conclusions. However, the results from the analyses of lexicalisation and neologistic responses are rather less clear with respect to the issue concerning the poor reader's approach to this task: the poor readers were found to make significantly more lexicalisation errors to the regular high frequency words and significantly fewer neologisms, and on the regular low frequency words they made significantly fewer lexicalisations than controls together with a similar number of neologisms. On the irregular high and low frequency words the poor readers, while making a similar number of lexicalisations to controls, made significantly fewer neologisms. Thus on these 2 categories of error the poor readers tend to make fewer neologistic responses than their controls, coupled with rather more lexicalisations. Since the tendency to make lexicalisations is regarded as being associated with difficulties in adopting a phonological approach this aspect of the results suggests that the poor readers are less adept at utilising this approach compared to controls. However, taken in conjunction with the other findings from this experiment too much weight should not be attached to this aspect of the error data; the fact is that the main result (i.e. accuracy data) demonstrates very clearly that these poor readers were influenced by spelling-to-sound irregularities in their ability to read these words.

EXPERIMENT 3: LEXICAL DECISION TASK: PSEUDOHOMOPHONES AND NON-WORDS

Method

Subjects

These were the same children who took part in experiment 2.

Procedure

Materials

These items were constructed by Johnston et al., 1987a and consisted of 24 pseudohomophones, 24 nonsense words, and 48 filler words (to equate the number of 'yes' and 'no' responses.). (See Appendix 3.) The pseudohomophones and non-words were derived according to Taft's (1982) criteria. Two words which were visually similar but had differing pronunciations of the vowel sounds were selected e.g. 'bear' and 'near'. The vowel digraph 'ea' was replaced with digraph 'ai' in both words, producing the pseudohomophones 'bair' and the nonword 'nair'. For each of these items, a control word was selected of similar length and word frequency to the original word (Carroll et al., Grade 3 norms). The mean word frequency for the words matched to the pseudohomophones was 509 (SD 14.55), and for those matched to the nonwords, 638 (SD 11.91). The items were presented on index cards in lower-case print.

Procedure

The children were told that the cards contained a mixture of real words and 'made up' words. They were asked to put the real words into one pile and the made-up ones into another pile as quickly and as carefully as possible. Before being given the entire pack, consisting of a randomised ordering of the words and nonwords, some practice at the task was given. The children were given a set of 8 cards, 4 of which had words written on them, the rest consisting of an equal number of nonwords and pseudohomophones. The child was then asked to place the items on the table in separate piles. When the child misclassified a pseudohomophone as a word this was discussed. It was pointed out that just because it sounded like a real word it was not necessarily a word; the spelling of the pseudohomophones was not commented upon. The other misclassifications that occurred were also discussed, but as these were rare it was generally only the misclassifications of pseudohomophones that were pointed out.

Each child received the entire set of 96 items in a different random order. This was accomplished by shuffling the cards before each testing session. No feed-back was given as to the correctness of the classifications during the experimental trials.

Results

Lexical decision accuracy

The data were expressed as the percentage correct for pseudohomophones and nonwords. A 2 way analysis of variance with repeated measures was then carried out on these data. There was one between subjects factor, groups (poor readers and reading age controls), and there was one within subjects factor, nonword types (pseudohomophones and nonwords). See Table 8 for means and standard deviations.

No between groups difference was found, $F < 1$. However, there was a main effect of type of non-word, $F(1,38) = 69.85$, $p < .001$, pseudohomophones being significantly more likely to be misclassified as words than non-words. The lack of a group by type of non-word interaction, $F < 1$, indicates that both groups showed a pseudohomophone effect to the same extent.

Discussion

In experiment 3 the poor readers were found to behave in a very similar manner to their reading age controls: both groups showed pseudohomophone effects. It follows from this that in this silent reading task the poor readers access phonological codes from print as do their controls and that they do not differ in the extent of their reliance upon phonological information.

EXPERIMENT 4: NAMING TASKS (NON-WORDS)

Method

Subjects

These were the same children who took part in experiment 2 and 3.

Materials

For the sets of non-words used in these 4 tasks see Appendix 3, 4, 5 and 6.

Experiment 4(i): Johnston, Rugg and Scott's pseudohomophones/non-words

These were the 24 pseudohomophones and 24 non-words used in experiment 3. All children took this pronunciation task before they carried out the lexical decision task.

Experiment 4(ii): Patterson's (1982) pseudohomophone/non-words

These were the 20 pseudohomophones and 20 non-words devised by Patterson (1982), and subsequently used by Temple and Marshall (1983) in a study by developmental phonological dyslexia.

Experiment 4(iii): Temple and Marshall's (1983) pseudohomophones/non-words

These were a further set of 24 pseudohomophones and 24 non-words generated by Temple and Marshall (1983).

Experiment 4(iv): simple non-words

These were a set of 20 non-words 3 letters in length, none of which were homophonic with words, and devised by the present author.

Procedure

In all cases the non-words were printed in lower case on index cards, one item to a card. The items were randomised for each set by shuffling prior to testing. The children were asked to read the items at their own pace, and were told that all the items were "made up" words, but that they could still be read. Pronunciation errors were recorded by the experimenter, and later analysed according to whether the responses were lexicalisations or neologisms.

Data analysis

In order to analyse the accuracy data in experiments 4 (i), (ii) and (iii), the children's responses were expressed as the percentage correct within each type of non-word category. Two way repeated measures analyses of variance were then carried out on these data. There was one between subjects factor: groups (poor readers and reading age controls), and one within subjects factor: non-word type (pseudohomophones and non-words). The means and standard deviations for experiment 4(i) are shown in Table 9a, those for experiment 4(ii) in Table 10a and those for experiment 4(iii) in Table 11a.

Pronunciation errors were classified as lexicalisations or as neologisms in each of these experiments and expressed as a percentage of the errors to pseudohomophones and non-words. Three way repeated measures analysis of variance were then carried out. There was one between subjects factor: groups (poor readers and reading age controls), and 2 within subjects factors: non-word type (pseudohomophones and non-words), and error type (lexicalisations and neologisms). The means and standard deviations for these results are to be found in Tables 9(b), 10(b) and 11(b) respectively.

Results

Experiment 4(i)

Accuracy

A number of significant main effects were found. There was a main effect of groups, $F(1,38) = 5.42$, $p < .03$, the reading age controls being more accurate. There was also a main effect of non-word type, $F(1,38)$ - 165.24, $p < .0001$, pseudohomophones being read better than non-words. There was no interaction between groups and type of non-word, $F < 1$ in all cases. (The mean and standard deviations are to be found in Table 9a.)

Errors

Lexicalisations and Neologisms

No differences between groups were found, $F < 1$. There was a main effect of non-word type, $F(1, 38) = 8.23$, $p < .01$, with more errors occurring on the non-words than pseudohomophones. No other effects were significant. (The means and standard deviations are to be found in Table 9b.)

Discussion

In experiment 4(i) the poor readers were found to be significantly less accurate at naming the Johnston et al. stimuli compared with their reading age controls. Thus considered at its face value this result suggests a deficit in the ability of the poor readers to rely upon a phonological strategy. Both groups were, however, similar in terms of the fact that they found the pseudohomophonic non-words significantly easier to name than the ordinary non-words. The types of errors made by both groups did not distinguish them either: the poor readers made a similar number of neologistic and lexicalisation errors to their reading age controls. Thus in terms of these errors the groups would not appear to differ qualitatively in the way in which they approached these nonsense words.

Experiment 4(ii)

Accuracy

A number of significant main effects were found. There was a main effect of groups, $F(1,38) = 41.47$, $p < .0001$, with the reading age controls being more accurate than the poor readers. There was also a main effect of type of non-word, $F(1,38) = 7.8$, $p < .01$, pseudohomophones being read better than non-words. There was no interaction between groups and non-word type, $F < 1$. (The means and standard deviations are to be found in Table 10a.)

Errors

Lexicalisations and neologisms

No significant effect of groups was found, $F < 1$, although more neologisms than lexicalisations occurred, $F(1,38) = 5.78$, $p < .02$. However, there was an interaction between error type and groups, $F(1,38) = 12.09$, $p < .002$. Newman Keuls tests showed that poor readers made fewer lexicalisations than controls, and more neologisms. No other main effects or interactions were significant. (The means and standard deviations are to be found in Table 10b.)

Discussion

In experiment 4(ii) the poor readers were found to be significantly worse than their reading age controls at reading the Patterson non-words. This result confirms the finding from the previous experiment: in other words, the poor readers (in terms of the received position) would appear to have problems in using their non-lexical reading skills effectively. As in the previous experiment the groups behaved similarly with regard to finding pseudohomophones easier to name than the ordinary non-words. However, in contrast to the previous experiment the poor readers made significantly more neologisms than their reading age controls and significantly fewer lexicalisations.

Experiment 4(iii)

Accuracy

A main effect of groups was found, $F(1,38) = 43.78$, $p < .0001$, the reading age controls WERE significantly better than the poor readers. There was also a significant effect of type of non-word, $F(1,38) = 51.31$, $p < .0001$, favouring the pseudohomophones. These factors did not interact, $F < 1$. (The means and standard deviations are to be found in Table 11a.)

Errors

Lexicalisations and neologisms

More neologistic than lexicalisation responses occurred, $F(1,38) = 6.57$, $p < .02$. There were no significant effects of groups or non-word type, $F < 1$, but there was a significant 3 way interaction between groups, non-word type and type of error, $F(1,38) = 5.07$, $p < .03$. Newman Keuls tests showed that the poor readers made fewer lexicalisations to non-words than controls, and more neologisms. No group differences were found on the pseudohomophones, and no other main effects or interactions were significant. (The means and standard deviations are to be found in Table 11b.)

Discussion

In experiment 4(iii) the findings were remarkably similar to those from the previous experiment: the poor readers were significantly less accurate than their reading age controls at reading the Temple and Marshall non-words. Also, both groups were found to be significantly more accurate on the pseudohomophones compared with the ordinary non-words. In addition, the poor readers made significantly more neologisms than controls and significantly fewer lexicalisations.

Experiment 4(iv)

Results

Accuracy

The data were expressed as percent correct, and a one way analysis of variance was carried out. There was one between subjects factor: groups (poor readers and reading age controls). No between group differences were found, F

< .1. (Means and standard deviations are to be found in Table 12a.)

Errors

Lexicalisations and neologisms

A 2 way analysis of variance was carried out on these data. There was one between subjects factor: groups (poor readers and reading age controls), and one within subjects factor: error type (lexicalisations and neologisms). No group differences were found, $F < 1$, but there was a main effect of type of error, $F(1,38) = 13.69$, $p < .001$, more neologistic responses than lexicalisations being made. There was no interaction between groups and type of error. (Means and standard deviations are to be found in Table 12(b).)

Discussion

In experiment 4(iv) the poor readers were found to be as accurate as their reading age controls at reading 3 letter non-words. These results are in direct contrast to the findings from the 3 previous studies (i.e. experiments 4(i), 4(ii) and 4(iii) where the poor readers were found to be impaired at reading more complex non-words. Also in contrast with the findings from these experiments the poor readers, like their controls, made significantly more neologisms than lexicalisations. Taken together both these results indicate that the poor readers can use a phonological strategy effectively and behave normally given their level of reading ability (i.e. they perform like their reading age controls).

GENERAL DISCUSSION

The general concern of the experiments reported in this chapter has been to explore in greater detail the reading strategies of young poor readers in order to provide a more accurate characterisation of the nature of their reading difficulties. The studies involving the first sample of poor readers (see chapter 5) demonstrated the existence of regularity effects in conjunction with impaired non-word naming. The poor readers who are described in the present chapter exhibit a similar pattern of performance suggesting that the form of the reading deficiency in both samples is comparable. Further support for the conclusion that the poor readers relied upon a phonological strategy was found on a variety of indices of non-lexical reading: for example, apart from showing regularity effects these 8 year old poor readers were not found to differ from their reading age controls in terms of regularisation errors. They were also virtually indistinguishable from their control group in experiment 3 where they showed significant effects of pseudohomophony on lexical decision. It is very clear in the light of these results that these poor readers did utilise phonological information in processing both words, and also non-words.

For this reason these findings are compatible with the conclusions of some other research which also discovered that poor readers relied upon a phonological approach (e.g. Beech and Harding, 1984; Treiman and Hirsh-Pasek, 1985; Johnston, Rugg and Scott, 1987a). These results therefore conflict with other workers' assessments of their difficulties where it is argued that they suffer from a phonological dysfunction (e.g. Snowling, 1980, 1981; Frith, 1985).

Thus if it is the case that poor readers are not to be regarded as using aberrant reading strategies then they would also be expected to exhibit a particular performance pattern on several other traditional indices of non-lexical reading: for instance, one would predict that they would make more neologisms than lexicalisations and be as proficient as reading age controls at reading non-words. The fact is however that the poor readers in this study were found to differ from their reading age controls on these measures of phonological reading in some situations, and for this reason it is uncertain as to whether they do or do not differ qualitatively from their reading age controls in terms of their phonological reading abilities. For example, in experiment 2 the poor readers made more lexicalisation errors than their reading age controls and fewer neologisms, which implies a subtle difference in processing style of these groups with the poor readers displaying a bias towards a "logographic" approach. Indeed a close inspection of the character of the poor readers' errors on the non-word naming experiment (i.e. experiments 4(i) to 4(iv)) indicates a degree of instability in their adherence to a lexical or to a non-lexical strategy; in experiment 4(i), for example, they did not differ from their controls in terms of lexicalisation and neologistic responses, whereas in experiments 4(ii) and 4(iii) they made significantly more neologisms than their controls, and in experiment 4(iv) a similar number of neologisms compared with controls. That they tended to make more neologisms than controls on some of these non-word naming tasks suggests a surface dyslexic reading style i.e. an over-reliance upon phonological mediation. The main difficulty with accepting this conclusion however is connected with the finding that they were worse than their reading age controls at naming the more complex non-words. If it were actually the case that they over-relied upon a phonological strategy then one would expect them to be at least as able at naming all classes of non-word as their reading age controls.

One way to seek to resolve the incompatible nature of these results is to question the general validity of relying upon lexicalisation and neologistic response errors as a means of acquiring accurate information about patterns of reading deficit which is an accepted practice in the study of reading pathology (e.g. Marshall, 1982, 1976; Coltheart, 1981a).

Henderson (1981), in a critical review of studies of acquired deep dyslexia, suggested that "all of the acquired dyslectics reading performance may be mediated by strategies that are inventions peculiar to these patients" (p. 518); in other words, their errors are not necessarily outcomes of a structured breakdown in the normal reading system as those involved in research in this field typically assume. Seymour (1986), in his study of children who were competent and impaired readers, found "no consistent association between predominance of a phonological dyslexia and a preference for production of word responses. Also, one of his subjects who was a relatively clear case of "morphemic" dyslexia (i.e. surface dyslexia) "did not exhibit a bias towards production of non-word responses". Thus on the basis of such results Seymour concluded that the "analysis of error types ... failed to support the theory of compensations" and therefore that "the psycholinguistic analysis of error types ... which has become standard in the investigation of the acquired dyslexias cannot be used as a secure basis for the classification of developmental disorders" (see also Ellis, 1985).

It follows from these arguments that one should be cautious before attaching too much weight to the errors made by these children. In line with Henderson's remark it is possible that the poor readers in the present study made more neologisms compared with reading age controls on some of the non-word tasks because being older they may have been able to monitor their own performance more closely so that it matched task instructions; that is, they could keep in mind the point that these were all non-words and so be in a better position to recognise that word responses (i.e. lexicalisations) would be inappropriate than the reading age controls who were about 18 months younger.

Quite apart from these uncertainties about the theoretical status of error types was the interesting finding that these poor readers were proficient at reading simple non-words, but not the more complex non-words. The data from experiments 4(i) to 4(iii) supports the view that poor readers have a phonological deficit since they were impaired at naming the stimuli used in these experiments. However, as the poor readers were as proficient as controls at reading certain types of non-word (i.e. 3 letter ones) this suggests that they can utilise a phonological strategy. It is possible that their difficulties connected with the more complex items are linked with visual segmentation inefficiences which may not be sufficiently severe to impede performance on simpler items (see Clifton-Everest, 1976). However, whether this is in fact the case cannot be resolved on the basis of the data from these experiments. (See chapter 8 for an account of a visual-orthographic segmentation task.)

Another possible contributory factor to their non-word difficulties may be associated with speech related impairments. For example, Montgomery (1981) demonstrated that poor readers have a weak awareness of what their articulators are doing when they produce a given sound. This weakness would result in a poorer grasp of phonemes since these can be regarded as being represented as sensations in the mouth as sounds are produced. Snowling (1981) found that poor readers were worse than their reading age controls at repeating phonologically complex non-words. Thus the results of these 2 studies are consistent with the idea that some poor readers suffer from a deficit involving speech motor sequencing (see also Tallal, 1980). However, if it were the case that the present sample of poor readers also experienced such impairments we would predict that they would be as capable as reading age controls at reading pseudohomophonic non-words since these have pre-existing speech-motor programmes associated with them. Instead, the poor readers were significantly worse at naming the pseudohomophonic items and the ordinary non-words compared with controls and for this reason this account cannot be correct.

Another possible source of their weak performance on complex non-words may be associated with their memory spans which were found to be significantly shorter than their reading age controls (see chapter 9). Baddeley (1979) has suggested that working memory may be particularly important during the early stages of literacy development where grapheme-to-phoneme decoding is important in word recognition. For this reason it is conceivable that these poor readers' immediate memory impairments could compromise the efficiency with which they could successfully exploit a phonological strategy. In connection with 3 letter nonwords the degree to which these items tap memory processes would seem minimal and this may help to explain why they did not find these items difficult. However, this account is very speculative both because the research reported in this thesis offers no independent support for it and since there is no empirical study which has demonstrated a causal relationship between intact working memory processes and non-word reading effectiveness.

Finally, in the previous chapter it was proposed that poor readers may have deficient segmentation skills and that such skills may play a critical role in processing non-words. As there were similarities between the 2 samples of poor readers on the reading tasks this kind of explanation would appear to be applicable again to the 8 year old poor readers examined in this chapter. If one considers the phonological reading route as a "multi-level system in which word-form units of a number of different sizes can be translated into a phonological form" as proposed by Shallice, Warrington and McCarthy (1983) it follows that there could be individual differences with respect to the size of the parsing conducted on the written input strings. This conception contrasts with a much narrower view of the phonological route expressed by Coltheart, Masterson, Byng, Prior and Riddoch (1983) where the input string is parsed into "functional spelling units" in Venezky's (1970) sense (i.e. 'low level' individual grapheme-to-phoneme mappings). The poor readers may have been able to deal adequately with simpler non-words because their more basic phonic reading skills could cope with the demands inherent in reading these items. However, in order to name the complex non-words a sensitivity to higher levels of segmentation (i.e. parsing) may be mandatory. Thus unlike their reading age controls the poor readers may have been incapable of using these higher levels (and/or detecting them in non-words) and this may account for their inferior performance on these items. If this is the case it would seem to imply some defect in the development of the non-lexical route in poor readers the exact nature of which would have to be determined by further research. Apart from the possibility that non-word naming problems are associated with visual segmentation deficiencies there is also the possibility that in order to become aware of more sophisticated forms of segmentation one's level of phonemic awareness must be appropriate. These poor readers were indeed found to differ in their degree of phonemic awareness compared to these controls in a task requiring phonemic segmentation (see next chapter). For this reason it is possible that aspects of their difficulties with naming non-words are traceable to their problems in other areas of cognitive functioning. In the following chapter these childrens' spelling difficulties are examined in relation to their phonemic segmentation skill.

TABLE 4

Mean Age, Reading Age, Spelling Age and I.Q. Level of Groups

	Chronological Age	Reading Age	Spelling Age	I.Q.
Eight year old poor reader group:	8.6 (4.54)	7.0 (3.81)	7.4 (6.37)	103.65 (9.29)
Reading age control group:	7.2 (3.18)	7.2 (2.25)	7.4 (5.06)	107.7 (14.9)

@ SD in parentheses

TABLE 5

Mean Percentage Correct, Naming Regular and Irregular Words

	Regular Words		Irregular Words	
	high frq.	low frq.	high frq.	low frq.
Eight year old poor readers:	67.6 (17.6)	51.3 (18.3)	56.7 (20.1)	29.3 (13.6)
Reading age controls:	67.6 (14.4)	51.3 (18.7)	57.7 (16.4	32.2 (9.2)

@ SD in parentheses

TABLE 6

Mean Percentage Errors: Lexicalisations (L) and Neologisms (N)

	Regular Words				Irregular Words			
	high frq.		low frq.		high frq.		low frq.	
	L	N	L	N	L	N	L	N
Poor readers:	61.5 (31.3)	26.15 (25.5)	44.35 (23.1)	33.9 (25.5)	47.1 (27.0)	37.6 (24.4)	31.1 (21.4)	42.9 (19.2)
Reading age controls:	40.1 (28.1)	49.8 (26.8)	57.6 (27.1)	36.8 (26.1)	37.1 (22.4)	55.2 (22.1)	23.7 (20.5)	64.4 (25.3)

@ SD in parentheses

NOTE: ALL OTHER ERRORS WERE REFUSALS.

TABLE 7

Mean Percentage Errors: Regularisation

	Irregular Words	
	high frq.	low frq.
Eight year old poor readers:	29.7 (25.6)	31.75 (18.7)
Reading age controls:	34.8 (26.4)	46.7 (25.7)

@ SD in parentheses

TABLE 8

Mean Percentage Correct: Lexical Decision

	Pseudohomophones	Non-Words
Eight year old poor readers:	49.0 (18.0)	70.2 (14.7)
Reading age controls:	49.8 (18.2)	72.3 (15.6)

@ SD in parentheses

TABLE 9(a)

Percentage Correct Pronunication of Non-Words (Experiment 4(i))

	Pseudohomophones	Non-Words
Eight year old poor readers:	69.0 (18.6)	50.95 (22.9)
Reading age controls:	82.0 (8.3)	60.6 (13.5)

NOTE: ALL OTHER ERRORS WERE REFUSALS.

@ SD in parentheses

TABLE 9(b)

Mean Percentage Errors: Lexicalisations (L) and Neologisms (N) (Experiment 4(i))

	Pseudohomophones		Non-Words	
	L	N	L	N
Eight year old poor readers:	34.3 (23.8)	48.1 (29.8)	44.7 (44.0)	43.1 (23.4)
Reading age controls:	45.7 (29.9)	39.3 (29.3)	47.3 (24.5)	45.9 (24.5)

NOTE: ALL OTHER ERRORS WERE REFUSALS.

TABLE 10(a)

Mean Percentage Correct Pronunciation of Non-Words (Experiment 4(ii))

	Pseudohomophones	Non-Words
Eight year old poor readers:	48.5 (16.2)	40.8 (20.9)
Reading age controls:	76.8 (11.5)	70.8 (15.2)

@ SD in parentheses

TABLE 10(b)

Mean Percentage Errors: Lexicalisations (L) and Neologisms (N) (Experiment 4(ii))

	Pseudohomophones		Non-Words	
	L	N	L	N
Eight year old poor readers:	28.8 (18.3)	61.8 (24.6)	23.0 (15.8)	64.0 (23.0)
Reading age controls:	43.85 (27.1)	41.10 (41.1)	51.8 (30.2)	41.0 (29.7)

NOTE: ALL OTHER ERRORS WERE REFUSALS

@ SD in parentheses

TABLE 11(a)

Percentage Correct Pronunciation of Non-Words (Experiment 4(iii))

	Pseudohomophones	Non-Words
Eight year old poor readers:	60.5 (17.0)	48.3 (17.2)
Reading age controls:	85.9 (8.6)	76.7 (9.6)

NOTE: ALL OTHER ERRORS WERE REFUSALS.

@ SD in parentheses

TABLE 11(b)

Mean Percentage Errors: Lexicalisations (L) and Neologisms (N) (Experiment 4(iii))

	Pseudohomophones		Non-Words	
	L	N	L	N
Eight year old poor readers:	33.4 (24.3)	57.1 (27.3)	31.6 (21.0)	58.3 (22.7)
Reading age controls:	30.75 (32.1)	57.0 (36.9)	40.9 (23.7)	48.6 (24.4)

NOTE: ALL OTHER ERRORS WERE REFUSALS.

@ SD in parentheses

TABLE 12(a)

Percentage Correct Pronunciation of Non-Words (Experiment 4(iv))

	Non-Words
Eight year old poor readers:	81.75 (21.9)
Reading age controls:	87.00 (9.9)

@ SD in parentheses

TABLE 12(b)

Mean Percentage Errors: Lexicalisations (L) and Neologisms (N) (Experiment 4(iv))

	Non-Words	
	L	N
Eight year old poor readers:	17.7 (32.3)	48.6 (45.3)
Reading age controls:	17.1 (28.16	60.3 (43.8)

NOTE: ALL OTHER ERRORS WERE REFUSALS.

@ SD in parentheses

CHAPTER 7

The purpose of the 2 experiments described in this chapter is to extend the research concerned with spelling difficulties, reviewed in chapter 3. By doing so it also extends the research of the 2 previous chapters which dealt with the nature of poor readers' word recognition difficulties since it explores phonological processes involved in spelling words. The application of a cognitive model of the spelling process enables us to improve upon much previous research as it allows one to make more accurate predictions about what follows from any particular impairment to the spelling system. The present experiments rely upon a dual route model of spelling which postulates 2 parallel mechanisms, one lexical and one non-lexical (i.e. phonological) involved in oral and written spelling (Frith, 1980; Nelson, 1980; Ellis, 1982, 1984; Gerber and Hall, 1987; Caramazza, Miceli and Villa, 1986; Goodman-Schulman and Caramazza, 1987; Baxter and Warrington, 1987; Margolin, 1984; Shallice, 1981). The phonological mechanism translates phonemes to graphemes and is involved in spelling regular words and non-words. The lexical mechanism uses a whole-word address system and is involved in spelling irregular words.

Cognitive deficits which implicate either of these 2 mechanisms give rise to particular forms of spelling disability and residual ability. Deficiencies involving the lexical mechanisms are reflected in regular words being spelt more accurately than irregular words; also non-words are better spelt than irregular words. Spelling errors tend to be phonologically similar to the target (e.g. "serfiss" for surface) indicating reliance upon the phonological routine (Beauvois and Derouesne, 1981; Roeltgen and Heilman, 1984; Hatfield and Patterson, 1983). By contrast deficiencies which impair the non-lexical routine give rise to non-word spelling difficulties, regular words not being spelt better than irregular words. Spelling errors which bear little or no relation to the sound of the target word are predominant (Shallice, 1981; Roeltgen et al., 1983; Temple, 1986).

Up until relatively recently the application of this approach has been largely in connection with spelling disorders found in brain damaged patients. However, as argued in chapter 3 it is possible to adopt a similar approach in relation to developmental disorders of spelling. In chapter 3 the main evidence favouring a phonological deficit view of spelling difficulties in children tended to focus upon the nature of their spelling errors. It was also pointed out that firm conclusions for or against this hypothesis were difficult since not all studies found a preponderence of non-phonetic errors in poor readers. A further methodological difficulty hampered the task of assessing the conclusions reached in these studies since many of them failed to employ spelling age controls. An examination of previous research demonstrated an intimate association between spelling and phonemic segmentation ability (see Perin 1983; Ellis and Large, 1987). Although literacy problems in children are not invariably associated with phonemic segmentation difficulties (see e.g. Beech and Harding, 1984 for an exception) the bulk of the evidence does suggest that most poor readers/spellers are worse than achievement-matched controls on tasks involving phonemic segmentation (e.g. Bradley and Bryant, 1978, 1983, 1985).

Given the possibility of a causal connection between success at using a phonological spelling strategy and phonemic segmentation skill it would seem not unreasonable to expect that if poor readers/spellers were found to make more non-phonetic errors than spelling age controls then they may also be significantly worse at phonemic segmentation. The predictions upon which the present 2 experiments are based can now be stated: in the first experiment (i.e. 5) the groups are given an experimental spelling task and if the retarded group are found to make a greater number of non-phonetic errors than their controls then it is predicted that in the next experiment (i.e. 6) they will perform at an inferior level compared to controls since that experiment examines phonemic segmentation. The advantage of using two tasks to pinpoint the source of their spelling difficulties is connected with the fact that these measures are complementary to one another.

In the first experiment the children were asked to spell to dictation 30 regular and 30 irregular words matched for frequency. In the second experiment they carried out a phonemic segmentation task originally devised by Bradley and Bryant (1978).

EXPERIMENT 5 SPELLING - REGULAR AND IRREGULAR WORDS

Method

Subjects

These were the same children that were used in the experiments described in the previous chapter (i.e. 6).

Materials

These were the same regular and irregular words that were used in the 2 previous chapters (see Appendix 1).

Procedure

The stimuli were divided into 3 separate lists each consisting of 20 words, and these lists were counterbalanced for frequency and regularity. The children were told they were going to spell some words and should listen carefully. The experimenter read each word aloud once, then included it in a sentence and repeated the word again on its own. To guarantee the child heard the word, he or she was told to repeat it before writing it down. The test was conducted at the child's own pace. The task was given in a single session with a break of about 20 minutes half way through the 60 words. Testing was on an individual basis in the child's school and lasted about 45 minutes. (All children took this task about 3 months after experiment 2.)

Results

Accuracy

These data were expressed as the percentage correct and subjected to a 3-way repeated measures analysis of variance. There was one between subjects factor: groups (poor readers/spellers and reading/spelling age controls). There were 2 within subjects factors: regularity (regular and irregular words), and frequency (high and low). See Table 13 for means and standard deviations.

A number of significant main effects were found. Overall, regular words were spelt more accurately than irregular words, $F(1,38) = 69.34$, $p < .0001$ and performance on high frequency words was better than on low frequency words, $F(1,38) = 17.66$, $p < .0002$. No between group differences were found, $F < 1$, and there was a non-significant interaction between groups, regularity and frequency, $F(1,38) = 2.07$, N.S.

Errors

Phonetic accuracy/inaccuracy

The childrens' error responses were classified as phonetically accurate from the viewpoint of the reader as well as the speller. From the point of view of the reader the question is: does the spelling, when read aloud, sound like the target word? Thus the spelling "gait" for the target "gate" would qualify as phonetically accurate. Using only this criterion a spelling like "frot" for the target "fruit" is phonetically inaccurate and so is the spelling "grat" for the target "great". From the viewpoint of the speller however both renderings could be regarded as phonetically accurate since with regard to the former example (i.e. "frot") "o" is a common spelling of /u/ (e.g. "do", "to"). Similarly, with regard to the other example (i.e. "grat") "a" is found in e.g. "baby". To assist in the classification process reference was made to the norms of English orthography supplied by Hanna, Hanna, Hodges and Rudorf (1966). By examining phonetic accuracy using both yardsticks we were able to guard against the possible confound that the poor spellers, because they were also poor readers, may tend to make more errors which are only phonetically acceptable from the speller's viewpoint. All the other errors which violated these 2 criteria were classified as nonphonetic errors.

Statistical analysis

The nonphonetic errors were expressed as a proportion of the total errors and subjected to a 3 way analysis of variance. (See Table 14 for means and standard deviations.) There was one between subjects factor:

groups (poor readers/spellers and reading/spelling age controls). There were 2 within subjects factors: regularity (regular and irregular words), and frequency (high and low).

There was a main effect of groups, $F(1,38) = 7.80$, $p < .01$, with the poor readers/spellers making significantly more phonetically inaccurate spelling errors. There was also a main effect of regularity $F(1,38) = 93.99$, $p < .0001$, more phonetically inaccurate responses occurring to regular words. There was also a main effect of frequency, $F(1,38) = 5.32$, $p < .03$, more phonetically inaccurate responses occurring to low frequency words. However, frequency and regularity also interacted, $F(1,38) = 21.36$, $p < .0001$. Newman Keuls tests showed a frequency effect with regular words, such that more phonetically inaccurate errors occurred when these were low in frequency; no frequency effect was found with irregular words. The interaction between groups, frequency and regularity was not significant $F < 1$.

Discussion

In the experimental spelling test both groups were found to be significantly more accurate on regular words than irregular words. Since regular words are more predictable than irregular words in terms of phoneme-to-grapheme relationships this results suggests that the children in both groups made use of a phonological approach in spelling both word classes. The overall accuracy levels of both groups was also very similar which indicates that they were appropriately matched on spelling age. Since the poor readers also exhibit a spelling regularity effect it would appear that they cannot be regarded as suffering from an impaired non-lexical routine. In the context of the present theoretical framework strong evidence for a deficit involving this route would have been the finding that they found regular words no easier to spell than irregular words.

However, the analysis of the groups' spelling errors does suggest qualitative differences in spelling strategy: here the poor readers/spellers were found to make significantly more non-phonetic errors compared to controls. Taken in conjunction with the fact that they showed a regularity effect this result is puzzling since non-phonetic errors are thought to highlight a flaw in the operation of the phonological strategy. In view of these 2 seemingly incompatible results it would appear that the poor readers/spellers do suffer from a mildly impaired phonological routine which is reflected in the greater degree of phonetic inaccuracy of their misspellings.

EXPERIMENT 6 - ODD WORD OUT TASK

Method

Subjects

These were the same children as in experiment 5.

Materials

These comprised 3 different list types, each composed of 4 monosyllabic words per trial. There were 6 trials for each list type, making for a total of 18 experimental trials.

These 3 list types were:

1. Initial phoneme different: e.g. "pad, man, mat, mad."
2. Medial phoneme different: e.g. "dot, cot, pot, bat."
3. Final phoneme different e.g. "hat, sat, pat, bad."

The serial position of the target word (i.e. the odd word) was varied systematically in all 3 list types. (See Appendix 7 for these items.)

Procedure

The children were informed that they were going to hear some words. They were told to listen carefully, and to try to say which of the 4 words was different from the others. To ensure they understood the task each child received 3 practice trials, each of which represented one list type. The trials were presented in blocks, in the order Type 3, 2, and 1.

Results

These data were expressed as the percentage correct within each of the list types. A 2 way repeated measures analysis of variance was then carried out on these data.

There was one between subjects factor, groups (poor readers/speller and reading/spelling age controls). There was one within subjects factor, list type (initial, medial and final). (See Table 15 for means and standard deviations.)

A number of main effects were found. The controls were significantly better at detecting the target words than the poor readers/spellers, $F(1,38) = 4.15$, $p < .05$. In addition, there was a main effect of list type, $F(2,76) = 21.79$, $p < .0001$. However, these main effects were modified by an interaction between groups and list type, $F(2,76) = 6.68$, $p < .002$, and so the data will be described at this level. A Newman Keuls test was used to locate the source of the interaction. This revealed that the poor readers/spellers were as accurate as controls on the initial phoneme list (Type 1), but differed significantly from controls in being worse when the critical phoneme occupied a medial or a final position in the word (i.e. list types 2 and 3 respectively). Within groups, the controls performed less well on the initial phoneme list than on the final and middle phoneme lists, performance on these latter 2 lists being the same. The poor readers/spellers, however, performed similarly on all 3 list types.

Correlational analysis

Relationships between phonetically inaccurate errors and odd word out task performance

As the poor readers/spellers made more phonetically inaccurate spelling errors, and were poorer in selecting the target when the middle or final phoneme of a word differed, correlation co-efficients were calculated to determine if there was a significant association between these 2 factors.

Nonphonetic spelling errors and performance on the initial phoneme list (for both groups) was not significantly correlated, $r(38) = 0.1$, N.S. Similarly, no association was found between phonetically inaccurate errors and performance on the middle phoneme list, $r(38) = -.14$, N.S. However, there was a significant correlation between phonetically inaccurate spelling errors and performance on the final phoneme list, $r(38) = -.54$, $p < .001$. Thus the better the child was at detecting final phoneme differences, the less prone they were to make nonphonetic spelling errors.

Discussion

The results of experiment 5 were interpreted as indicating that the poor readers/spellers could use a phonological spelling strategy although less efficiently than their controls. A similar conclusion would be consistent with these childrens' behaviour on the reading tasks discussed in the previous chapter, which supports Boder's (1973) assumption that in children the cognitive processes used to read words are similar to those that they use to spell words, and therefore that the poor readers/spellers share a phonological deficiency which is common to spelling as well as reading. It could however be argued that the real source of the regularity effect is orthographic and not phonological since regular words also tend to be more predictable than irregular words in terms of their orthographic structure. If this were the case it would follow that one could not infer the use of a phonological approach solely on the basis of a spelling regularity effect, with the corollary that the poor readers/spellers may be even more impaired in their phonological skills than has been argued above. While this confound cannot be ruled out conclusively it would seem unlikely to conflict with the interpretation given of these results since the 2 word classes were matched in terms of bigram frequency which is a measure of gross orthographic structure.

That the poor readers/spellers were found to be significantly worse than controls at phonemic segmentation (i.e. experiment 6) supports the claim that it is the segmentation component of the non-lexical spelling routine which is impaired in these children, giving rise to the abnormal number of non-phonetic errors (cf. Frith, 1980). It is also of interest that the poor readers/spellers were only found to differ from controls in connection with the middle and final phoneme conditions on the odd word out task. This result provides striking confirmation of Bradley and Bryant's (1985) view that sensitivity to rhyme performance (i.e. middle and final phoneme tasks), and not awareness of alliteration (i.e. performance on initial phoneme task) is the crucial correlate of reading mastery. As Bradley and Bryant would predict, only rhyme serves to distinguish the poor readers/spellers from controls.

A point of further interest is the fact that some recent studies concerned with the development of "phonemic awareness" have found that very young children find manipulations involving phonemes in initial position in words particularly problematical: Content, Kolinsky, Morais and Bertelson (1986) found that preliterate 4 year olds have trouble in omitting consonants in initial rather than final position in a deletion task (see also Rosner and Simon, 1971; Bruce, 1964; Stanovich, Cunningham and Cramer, 1984). The 7 year old controls in the present study also found the initial phoneme task the most difficult which suggests that even with reading development the ability to cope with items in initial position continues to present problems (cf. Morais, Cary, Alegria and Bertelson, 1979). However, the poor readers/spellers failed to find the initial phoneme task significantly more difficult than the other tasks and the question arises as to why this was the case. The middle and final phoneme tasks differ from the initial phoneme task since lists of rhyming words are involved; the odd word can be identified in terms of its medial or final consonant in the final and middle phoneme tasks. Thus a sensitivity to rhyme would facilitate performance on these 2 tasks since once the "rhyme" is detected the deviant member of the series of 4 words is relatively easy to recognise.

Since the poor readers/spellers were found to be less sensitive to rhyme than controls this would help to explain why it was more difficult for them to perceive useful phonemic relationships among the 3 "distractor" words, and so the difficulty of detecting the target from the members in a series would be appreciably aggravated.

The main argument of this chapter is that the likely cause of spelling difficulties in these 8 year old poor readers is to be found in their impaired phonemic segmentation ability. Additional support for this conclusion comes from the correlational analysis where a statistical relationship was found between phonemic segmentation performance and non-phonetic errors. There was a significant negative correlation between performance on the final phoneme task and non-phonetic errors. Just why this task alone should correlate with these spellings errors is unclear, and cannot be resolved by the present study.

Finally it is possible that the nature of the phonological spelling strategy used by the poor readers/spellers imposed greater demands upon phonemic segmentation skills than was the case for the controls. Baxter and Warrington (1987) in their case study of an adult with acquired lexical agraphia suggested that their patient used multi-phoneme rather than single-phoneme units when spelling via the phonological routine. The controls in the present study may have been better at relying upon higher level sound-to-spelling relationships than the poor readers/spellers and by using these units they would be more likely to spell correctly targets which are not fully consolidated in their oral vocabulary. Campbell (1985) suggests that the ability of young children to utilise a phonological spelling strategy is not developmentally prior to their ability to exploit real word knowledge in spelling, and so the use of "rules" may actually index the child's level of achievement in literacy. If her account of spelling development is accepted then it would help to support the interpretation given in this chapter regarding why the poor reader/spellers could show a spelling regularity effect coupled with marked phonetic spelling inaccuracy.

TABLE 13

Mean Percentage Correct: Spelling Regular and Irregular Words

	Regular Words		Irregular Words	
	high frq.	low frq.	high frq.	low frq.
Eight year old poor readers/spellers:	39.0 (17.4)	29.7 (13.3)	22.4 (13.4)	16.0 (7.3)
Spelling/Reading age controls:	41.3 (13.2)	39.0 (20.6)	23.3 (10.2)	15.8 (7.9)

@ SD in parentheses

TABLE 14

Mean Percentage Errors: Phonetically Inaccurate

	Regular Words		Irregular Words	
	high frq.	low frq.	high frq.	low frq.
Eight year old poor readers/spellers:	52.6 (22.9)	66.8 (16.0)	34.4 (20.3)	35.5 (19.1)
Spelling/reading age controls:	40.5 (16.6)	56.2 (19.2)	29.8 (13.1)	22.5 (9.9)

@ SD in parentheses

TABLE 15

Mean Percentage Correct: Odd Word Out Task

	Initial phoneme	Middle phoneme	Final phoneme
Eight year old poor readers/spellers:	51.9 (19.5)	57.3 (25.6)	65.6 (22.0)
Spelling/reading age controls:	43.9 (25.0)	75.5 (15.0)	84.0 (18.4)

@ SD in parentheses

CHAPTER 8

CASE STUDIES OF 2 CHILDREN

In chapter 2 a review of the research which addressed reading and spelling difficulties in childhood in terms of an intensive case study approach revealed that there are wide variations in the nature of the literacy impairments afflicting these children. For instance, Temple and Marshall (1983) reported a case of a child whose reading difficulties resembled those found in connection with acquired phonological dyslexia. Evidence of a qualitatively different cluster of reading difficulties was reported Coltheart et al (1983) in their examination of a child whose disorder was similar to that found in patients with acquired surface dyslexia. In the field of spelling difficulties Temple (1986) described 2 children one of whom bore a resemblance to patients with acquired phonological dysgraphia, and the other to patients with acquired surface dysgraphia. With the possible exception of the study by Temple (1986) neither of the other two case studies allowed one to estimate the extent to which the difficulties experienced by the individuals examined were or were not representative of the difficulties experienced by the wider population of poor readers. Also, since they did not use control groups it was impossible to evaluate the degree to which the reading behaviours which they manifested were abnormal, and for that reason indicative of the causes of their retardation.

However, in a very recent study by Bryant and Impey (1986) the latter defect was rectified, allowing this assumption to be addressed directly. Bryant and Impey found very similar processing biases among their control group which consisted of perfectly normal children of similar levels of achievement in reading. For this reason they concluded that the data presented by Temple and Marshall (1983) and Coltheart et al (1983) do not demonstrate that their cases are approaching reading tasks in an abnormal manner. It follows from this that it was totally unwarranted to assume (as the authors of these two case studies appeared to have done) that the source of the two cases' reading difficulties were reflected in their reading strategies. Both cases (i.e. H.M. and C.D.) were, however, found to be significantly worse than their reading age control group at processing non-words which supports the view advanced by Snowling (1983) that grapheme-to-phoneme skills are impaired in dyslexic children. Temple (1986) also found evidence of phonological deficiencies in one of her 2 cases which were not found among the spelling age control group. Temple (1985) has speculated that, as far as the question of incidence of a sub-type of dyslexic child is concerned, most poor readers are most appropriately characterised by reference to acquired phonological dyslexia, and the available data provided by these case study investigations is consistent with her conjecture.

The difficulty associated with evaluating the validity of Temple's (1985) assertion is connected with the fact that neither Bryant and Impey (1986) nor Temple (1986) compared the performances of the retarded individuals with a group of dyslexic/dysgraphic children. One way of tackling the question of the representativeness of a child with a particular kind of literacy impairment is systematically to make such a novel comparison, and if a particular difficulty happens not to be found among the retarded group then this would suggest that the impairment in question is rather rare. In the present chapter an attempt is made to examine the extent to which children with symptoms of "phonological" dyslexia/dysgraphia are typical of the larger population of children experiencing reading/spelling problems. The studies presented in this chapter aim to achieve this by comparing the performance of 2 girls with "phonological" dyslexia/dysgraphia with a group of poor readers/spellers and also their reading/spelling age controls. (These 2 groups are described in chapter 6). The 2 girls who constitute the main focus of the studies described in this chapter were encountered in the course of selecting the groups of poor readers/spellers.

EXPERIMENT 7

Case Studies: Background History

Case 1: M.B.

This child was given several experimental and standardised tests over a 2 year period. Testing commenced when she was aged 8 years and 10 months. As a result of her poor educational progress, observed by her teachers, she was referred to her family doctor who found that she had intact hearing, vision and central nervous system functioning. Her doctor then arranged for her to be given a neurological examination at a local hospital which revealed no evidence of brain damage. Her doctor did however find many letter reversals and number reversals in examples of her free writing. M.B. was born by caesarean section at 33 weeks and had a birth weight of 3 lbs 12 oz. Her speech seemed normal apart from the fact that she sometimes experienced mild articulation difficulties. Her remedial teacher who had known her over a period of several months had observed that although M.B. could grasp phonic drills she was unable to apply them successfully to word recognition. Her class teacher found that she was excellent at copying information from the blackboard, and was very good at drawing. She was completely unable to tell the time and had difficulty in responding accurately to questions which involve sequencing the months of the year.

As regards her performance on standardised tests, her I.Q. (WISC-R short form) was 118; dividing this into a Performance I.Q. and Verbal I.Q. resulted in scores of 129 and 109 respectively. In other words, her verbal I.Q. was considerably worse than her performance I.Q.. Her reading age according to the British Ability Scales test of single word pronunciation was 6 years 9 months. Eleven months later on the same test her reading age had improved by just one month. And, when tested for a third time on the B.A.S. test in March, 1986, some 16 months after her initial testing, her reading was again found to be 6 years 10 months. The majority of her attempts to decode the words in the B.A.S. test resulted in lexicalisation errors. Her phonemic awareness was also examined on a test of Sound Blending taken from a battery of tests (i.e. Illinois Test of Psycholinguistic Abilities by Kirk, McCarthy and Kirk, 1968). Her performance gave her a raw score which placed her at the level of a child aged 7 years 4 months. On a test of Visual Sequential Memory, also from Kirk et al (1968), she was found to score at the level of a child aged 6 years 6 months. Her spelling age according to the Schonell test (Schonell, 1971) was 7 years. As regards tuition she received help from a learning support teacher for about 6 hours each week in school. On the advice of an educational psychologist a phonic approach was recommended. Such assistance was given for about 2 years concurrently with the present tests.

Case 2: R.C.

This child was seen for a shorter time than M.B. because she was detected later in the course of the research. She was tested over a period of 12 months. R.C.'s chronological age was 8 years 9 months when testing started. Compared with M.B. very little could be found out about her background; most of the information concerning her derives from the tests given by the present author. Her I.Q. (WISC-R short form) was 94 (full scale I.Q.); her performance I.Q. was 92 and verbal I.Q. 97. On the B.A.S. test of reading her reading age was 6 years 10 months, on the test of Sound Blending (Kirk et al, 1968) she scored at the level of a child aged 5 years 3 months, and on the test of Visual Sequential Memory (Kirk et al, 1968) her raw score placed her at the level of a child aged 6 years 10 months. Her Schonell spelling age (Schonell, 1971) was 5 years 9 months. Although R.C. is presently receiving help for her educational backwardness, at the time of testing and throughout the testing period she had never received any extra tuition for her difficulties. (See Table 16 for details of the 2 cases chronological and reading ages and spelling ages as well as other standardised test results.)

TABLE 16

Age, Reading and Spelling Age and Standardised Test Results of M.B. and R.C.

	M.B.	R.C.
Chronological age	8.1	8.9
Reading age	6.9	6.1
Spelling age	7.0	5.9
I.Q. (full-scale)	118.0	94.0
I.Q. (verbal)	109.0	97.0
I.Q. (performance)	129.0	92.0
Sound blending	7.4	5.3
Visual sequential memory	6.6	6.1

CONTROL GROUPS

The 2 groups of children, poor readers and their reading age controls, described in chapter 6 were used to compare the performances of the 2 cases against on the majority of the experimental tasks. A subset of these 2 groups consisting of 10 poor readers and 10 reading age controls (selected at random) were used as the 2 control groups for the orthographic segmentation task. For details of these childrens' chronological ages, reading and spelling ages and I.Q.'s see Table 17.

TABLE 17

Mean Age, Reading Age, Spelling Age and I.Q. Levels of Control Groups used in Task 4

	Chronological Age	Reading Age	Spelling Age	I.Q.
Poor readers (n = 10)	8.7 (4.93)	7.1 (5.23)	7.0 (5.95)	108.7 (8.43)
Reading age controls (n = 10)	7.0 (3.65)	7.3 (5.49)	7.2 (5.51)	106.5 (10.03)

SD in parentheses

Methods

The children were asked to do a variety of tasks many of which have been described in previous chapters (see chapters 6 and 7). For convenience these tasks will be briefly described in the present chapter and following this description an outline of the rationale for the particular task will be provided. The 2 cases received these tasks in the same order.

Procedure

A total of 6 tasks were administered to the 2 cases which addressed reading, spelling, phonemic segmentation abilities and orthographic segmentation skill. Their administration was identical to that used in connection with the group studies (see chapters 6 and 7 for details).

Tasks: (Reading)

1 - Naming of Regular and Irregular Words

Each child was asked to read aloud a total of 30 regular words and a total of 30 irregular words. Evidence for the involvement of grapheme-to-phoneme operations in this task could be reflected in regularity effects (i.e. better performance on the regular words than the irregular words), and in regularisation errors on the irregular words. (See Appendix 1.)

2- Lexical Decision Task: Pseudohomophones and Non-Words (Johnston, Rugg & Scott's items)

Each child was asked to sort real words from non-words in a pack of 96 items. Half of the non-words were pseudohomophones. Evidence for the involvement of phonological processing in this task would be the finding that more false-positive errors would be made on the pseudohomophonic non-words than on the ordinary non-words. (See Appendix 3.)

3 - Naming Tasks: Non-Words

(i) Johnston, et al's items

Each child was asked to read aloud both pseudohomophones and ordinary non-words. There were 24 pseudohomophones and the same number of ordinary non-words. Evidence for impaired grapheme-to-phoneme skills in this task would be inferior performance at naming both types of non-word compared with the control group(s).

(ii) Simple Non-Words

Each child was asked to read aloud a set of 20 simple non-words none of which sounded like a real word. These non-words were each 3 letters in length. As with the previous set of non-words evidence for deficient grapheme-to-phoneme skills would be reflected in inferior performance relative to controls. (See Appendix 3.)

4 - Orthographic Segmentation

As this task did not figure in the group studies reported earlier its description and rationale will be given in detail. The task itself was made up of 3 subtests. In each of these Tests there were a total of 15 items. In the case of Tests 1 and 2 the test items were real words. However, the words in these Tests differed: for instance, in Test 1 the parent word (e.g. "piglet") consisted of 2 words the pronunciation of which (e.g. "pig" and "let") corresponded with the pronunciation which they receive when the parent word is named. This was not the case with the words belonging to Test 2 where the pronunciation of the lexical segments (e.g. "so" and "me") does not correspond with their pronunciation in parent words (i.e. "some"). The items comprising Test 3 were all non-words none of which sounded like real words. Each of these non-words contained a "hidden word" (e.g. "in" inside the non-word "brint"). (See Appendix 8 for these items.)

In administering this task the Test 1 and 2 items were combined to form a single pack which was then shuffled to ensure randomization of the items. All the items were printed in lower-case on separate index cards. After being shown an item belonging to Test 1 or 2 the child was asked to read it out loud and to indicate in some way that he understood the meaning of the word. The reason for this was to ensure that they knew the word and to rule out the possibility that the items were being regarded as non-words. Having shown the child a word, asked him to name it and indicated what it meant the experimenter then placed his hand over the word and said, "Can you split it up into 2 words and tell me what they are?" Once this instruction had been given the word was again shown to the child. He was then asked to identify the items as quickly as possible.

The administration of items belonging to Test 3 was somewhat different from that followed in connection with Tests 1 and 2. The children were not asked to name the non-words prior to attempting to identify the concealed word. They were informed of the fact that these were "pretend words" and not real words; having been told this he was asked to try to find the real word hidden in the pretend word as quickly as possible, and to say it out loud once he had identified it. All children received these Test 3 items in different random orders. Half of the children were given Test 3 to do first which was followed by Tests 1 and 2; the rest of the children started with Test 1 then Test 2 followed by Test 3. The children readily understood what was required and so after each of the Tests was explained to them via practice items of each type (none of which were used in the experiment) they were able to participate in the experiment. An entire testing session lasted about 30 minutes. The children were tested individually in their own schools.

The rationale for this task derives from theories about how we read non-words and, for this reason, it is designed to examine these children's impaired non-word processing skill in more detail. The task has not yet been applied in this way to poor readers. Supporters of dual route reading models would explain the difficulties shown by phonological dyslexics in terms of deficiencies involving grapheme-to-phoneme correspondence rules. By contrast, lexical analogy accounts of how we read non-words stress segmentation skills; - in other words, non-words are initially segmented as part of the analogical search process. Thus, lexical analogy theorists would be likely to account for the reading impairment associated with phonological dyslexia in terms of deficits connected with orthographic segmentation. Funnell (1983) however in her case study of an adult patient with very impaired non-word reading failed to find segmentation difficulties using tasks which were very similar to the present set, and concluded in favour of a dual-route account of phonological dyslexia. (See also Coltheart, 1985 for a discussion of her results.)

5 - Spelling: Regular and Irregular Words

These were the same words that were used in Task 1. They were presented to the 2 cases using the same procedures followed in experiment 5 (chapter 7). Evidence of a phonological spelling strategy (i.e. use of the non-lexical route) would be shown by a spelling regularity effect. If this effect were not found, and if the children's errors contained many non-phonetic attempts, this would indicate that spelling was being carried out via the lexical route or by a seriously deficient non-lexical route. The use of the lexical route by children of this level of spelling ability is atypical (see chapters 2 and 3) and would therefore suggest that their phonological skills were impaired.

6 - Phonemic Segmentation - Odd Word Out

The 2 cases were asked to detect the odd word in a series of 4 spoken words. This task is described in chapter 7 (experiment 6). The procedures used to administer the task are described in chapter 7 and these procedures were also followed in connection with the 2 cases. Particularly severe phonological impairments would be evidenced by poor performance relative to the group of poor readers.

Results

The main question which the studies reported in this chapter aim to address is whether the performances of the 2 cases of "phonological" dyslexia and dysgraphia are qualitatively different from the group of poor readers. Although the group of poor readers shows signs of phonological reading difficulties (as well as spelling and phonemic segmentation difficulties) they also exhibit clear signs of an ability to use non-lexical routines on certain tests (see chapters 6 and 7). Thus the poor readers in this group are far from being "pure" cases of phonological dyslexia/dysgraphia and, are in many respects like surface dyslexics. In order to determine whether the 2 cases are more clear-cut examples of phonological dyslexics/dysgraphics they will be compared with the mean performance of the group of poor readers. By reference to chapters 6 and 7 the reader can find more detailed information about the poor reader and reading age control groups on all these Tasks with the exception of Task 4.

1. Naming of Regular and Irregular Words

(a) Accuracy

The data pertaining to the performance of the 2 groups, and the 2 cases are shown in Table 18.

TABLE 18

Mean Percentage Correct Pronunciation of Regular and Irregular Words

	Regular		Irregular	
	high frq	low frq	high frq	low frq
Reading age controls	67.7	51.3	57.7	32.2
Poor reader group	67.6	51.3	56.7	29.3
M.B.	27.0	7.0	33.0	7.0
R.C.	27.0	7.0	27.0	13.0

Note: frq = frequency

Discussion

In the previous analysis (see chapter 6) the 2 groups were not found to differ from one another, and both groups were significantly more accurate in naming the regular words than the irregular words. By contrast, it is clear from Table 18 that both cases are unaffected by spelling-to-sound irregularity: neither child exhibits an advantage for regular words. A further difference between the 2 cases and both groups arises in connection with the overall levels of accuracy: both cases are considerably less accurate at naming regular and irregular words than the groups. This may be related to the lack of perfect matching on reading age: for example, M.B.'s reading age is 6 years 9 months, and R.C.'s 6 years 10 months whereas the poor reader group have a mean reading age of 7 years, some 2 to 3 months more advanced.

(b) Types of Pronunciation Errors

The results of the groups and the 2 cases performances in terms of the nature of their errors on the regular and irregular words used in Task 1 are to be found in Tables 19 and 20.

(i) Lexicalisation and Neologisms

TABLE 19

Mean Percentage Errors: Lexicalisations and Neologisms (L and N)

	Regular Words				Irregular Words			
	high frq		low frq		high frq		low frq	
	L	N	L	N	L	N	L	N
Reading age control	40.1	49.8	57.6	36.8	37.1	55.2	23.7	64.4
Poor reader group	61.5	26.1	44.3	33.9	47.1	37.6	31.1	42.9
M.B.	100.0	0.0	100.0	0.0	90.0	0.0	100.0	0.0
R.C.	90.0	0.0	79.0	21.0	100.0	0.0	92.0	8.0

Discussion

In the previous group analysis (see chapter 6) the poor reader group were found to exhibit a significantly larger number of lexicalisation responses than their reading age controls, and fewer neologistic errors. This pattern of performance was greatly magnified for the 2 cases and indeed M.B. made no neologistic responses at all.

(ii) Regularisations

TABLE 20

Mean Percentage Errors: Regularisations

	Irregular Words high frq	Irregular Words low frq
Reading age controls	34.8	46.7
Poor reader group	29.7	31.7
M.B.	0.0	0.0
R.C.	0.0	0.0

Discussion

From Table 20 it can be seen that both the groups are similar in terms of their production of regularisation errors, and the previous analysis (see chapter 6) demonstrated that they did not differ from one another statistically. By contrast, the 2 cases are strikingly different from the groups as they make no regularisation errors whatsoever.

2. Lexical Decision Task: Pseudohomophones and Non-Words

The data pertaining to the performance of the 2 groups, and the 2 cases can be found in Table 21.

TABLE 21

Mean Percentage Correct: Lexical Decision

	Pseudohomophones	Non-Words
Reading age controls	49.8	72.3
Poor reader group	49.0	70.2
M.B.	79.0	83.0
R.C.	50.0	37.0

Discussion

In the previous group analysis (see chapter 6) the 2 groups showed pseudohomophone effects. By contrast, it can be seen from Table 21 that only M.B. shows a very small pseudohomophone effect (i.e. is slightly more accurate on the ordinary non-words), whereas R.C. is quite different in that she is actually more accurate on the pseudohomophone non-words.

3(I). Naming Tasks: Non-Words

(a) Accuracy

(i) Johnston, Rugg and Scott items

The childrens' performance at pronouncing these stimuli are given in Table 22.

TABLE 22

Mean Percentage Correct: Johnston et al Non-Words

	Pseudohomophones	Non-Words
Reading age controls	82.0	60.6
Poor reader group	69.0	50.9
M.B.	8.0	12.0
R.C.	8.0	4.0

Discussion

The reading age controls read these items better than the poor readers (see chapter 6). From Table 22 it can be observed that the 2 cases were virtually unable to read these non-words, even compared with the poor reader group. Both the poor reader group and their reading age controls were significantly more accurate at naming the pseudohomophones than the non-words (see chapter 6) which was clearly not the case with the 2 girls. R.C. however, despite her weak performance overall was a little better at naming the pseudohomophones than the ordinary non-words.

(b) Types of Pronunciation Error

The errors in attempting to name the Johnston et al non-words were also analysed. By reference to Table 23 the results of this analysis can be found. The errors consist of lexicalisations and neologisms made to both types of non-word.

TABLE 23

Mean Percentage Errors: Lexicalisations and Neologisms (L and N)

	Pseudohomophones		Non-Words	
	L	N	L	N
Reading age controls	45.7	39.3	47.3	45.9
Poor reader group	34.3	48.1	44.7	43.1
M.B.	59.0	41.0	43.0	57.0
R.C.	50.0	0.0	52.0	0.0

Discussion

The poor reader group was not found to differ from their reading age controls in terms of these 2 error categories (see chapter 6). Both cases were not very different from the poor reader group in terms of their lexicalisation errors to both types of non-word; on the pseudohomophones, however they did make somewhat more of these errors than the poor reader group. As regards neologistic errors the 2 cases were very different from one another: in general M.B. made a similar number of these errors as the poor reader group, whereas R.C. made no neologistic errors at all.

3(II). Simple Non-Words

(a) Accuracy

The children's ability to read these items aloud are summarised in Table 24.

TABLE 24

Mean Percentage Correct Simple Non-Words

	Simple Non-Words
Reading age controls	87.0
Poor reader group	81.7
M.B.	60.0
R.C.	5.0

Discussion

According to the previous analysis (see chapter 6) the poor readers were as efficient at naming these simple non-words as their reading age controls. Both cases are worse than the poor reader group and R.C. is dramatically inferior to this group and to M.B. In fact R.C. is almost incapable of reading these 3 letter items.

(b) Types of Pronunciation Error

The errors made in trying to name these simple non-words by all the children are given in Table 25. These errors consist of lexicalisations and neologisms.

TABLE 25

Mean Percentage Errors: Lexicalisations and Neologisms (L and N)

	Simple Non-Words L	N
Reading age controls	17.1	60.3
Poor reader group	17.7	48.6
M.B.	37.0	62.0
R.C.	63.0	37.0

Discussion

The analysis described in chapter 6 found that the poor reader group were similar to their reading age controls in that both groups made more neologistic errors than lexicalisation errors on these non-words. Both the cases were different from each other and so their results will be discussed separately. M.B. made somewhat more neologistic errors than the poor reader group, but far more lexicalisation errors than them. However, she did show a greater tendency to make more neologisms than lexicalisations, as did the 2 groups. R.C. showed a clearer pattern of results in that she made fewer neologisms than the poor reader group (almost 50% fewer than M.B.) and considerably more lexicalisations than the poor reader group (almost 40% more than M.B.).

4. Orthographic Segmentation

The scores of all of the children involved in this task can be found in Tables 26 and 27. Table 26 gives the accuracy data and Table 27 the latency data.

TABLE 26

Mean Percentage Correct: Orthographic Segmentation

	Test 1 "piglet"	Test 2 "some"	Test 3 "brint"
Reading age controls (n = 10)	91.2 (3.61)	70.9 (21.38)	71.7 (10.66)
Poor reader group (n = 10)	91.6 (5.52)	76.4 (21.28)	65.6 (13.92)
M.B.	93.0	26.0	93.0
R.C.	86.0	33.0	33.0

@ SD in parentheses

TABLE 27

Mean Identification Times of Hidden Words (In Seconds)

	Test 1 "piglet"	Test 2 "some"	Test 3 "brint"
Reading age controls (n = 10)	1.56 (3.61)	2.58 (1.01)	3.36 (2.14)
Poor reader group (n = 10)	1.66 (0.65)	2.39 (0.83)	3.67 (1.63)
M.B.	0.79	2.21	1.40
R.C.	3.12	6.65	7.30

@ SD in parentheses

Data Analysis

For an item to be regarded as correctly processed in all 3 tests the lexical segments had to be read aloud correctly when the child was asked to tell the experimenter the 2 words he could split a given parent word into (i.e. Tests 1 and 2), and once he had found the hidden word (i.e. Test 3). The reaction time data were based on the items a child got correct. A stop watch was used to record these. Timing started from when the experimenter removed his hand from the target word and terminated when the child had responded.

Accuracy

These data were expressed as the percentage correct. The data for the poor reader group and their reading age controls were then subjected to a 2 way repeated measures analysis of variance. There was one between subjects factor: Groups (Poor Readers and Reading Age Controls), and one within subjects factor: Test Type (Test 1, Test 2, Test 3).

There was no main effect of groups, $F(1,18) = 0.32$, $p > 0.57$. However, there was a main effect of Test Type, $F(2,36) = 17.10$, $p < 0.0001$. There were no interactions to modify this main effect. Newman Keuls tests showed that Test 1 items (e.g. "piglet") were responded to with significantly greater accuracy than both the other test types. And these types (i.e. Tests 2 (e.g. "some") and 3 (e.g. "brint"), were not significantly different from each other.

Latency

The mean reaction time for the poor reader group and for their reading age controls were subjected to a 2 way repeated measures analysis of variance. There was one between subjects factor: Groups (Poor Readers and Reading Age Controls), and one within subjects factor: Test Type (Test 1, Test 2, Test 3).

There was no main effect of groups, $F(1,18) = 0.30$,

$p > 0.85$. However, there was a main effect of Test Type, $F(2,36) = 13.87$, $p < 0.0001$. (There were no interactions between group and Test Type, $F < 1$.) Newman Keuls tests showed that the children in both groups were significantly faster on Test Type 1 items than Test Types 2 and 3 items. Also, they were found to be significantly faster on Test Type 2 items compared with Test Type 3 items.

Summary of the Groups' Performances

The poor readers were not found to differ from their reading age controls on any aspect of this orthographic segmentation task as regards accuracy or latency. Moreover, both groups exhibited a very similar pattern of performance on the various Test Types: both groups were more successful on Test 1 items (e.g. piglet) than Test 2 (e.g. some) and Test 3 (e.g. brint) items. Both groups were also significantly quicker at identifying the segments in Test 1 items compared with Test 2 and 3 items. Only one difference was found between the accuracy and the latency scores: both groups were not found to be significantly more accurate on Test 2 versus Test 3 items, but they were found to be significantly faster on Test 2 versus Test 3 items.

Discussion

The results of the orthographic segmentation task strongly suggest that this small group of poor readers functions normally in terms of the segmentation requirements of this task. Both quantitatively and qualitatively they were found to be indistinguishable from their reading age controls.

Differences were however found on these test types between the 2 cases and the control groups which suggests that certain components of their segmentation skills were impaired. In terms of accuracy, the performance of both cases was very similar to that of the groups on test 1 items (e.g. "piglet"). However, on test 2 items (e.g. "some") both cases were much worse than the control groups. As far as their performance on test 3 items (e.g. "brint") were concerned the 2 cases were different from each other and the control groups: in contrast to R.C. M.B. was excellent at finding the hidden word, and was also considerably better than the control groups; R.C. clearly had great difficulty in detecting the hidden word compared with both M.B. and the control groups.

In terms of latencies, M.B. was again broadly similar to the control groups on test 1 items in being slightly faster. However, in comparison with her accuracy performance (see above) M.B. was found to be very similar to the control groups on test 2 items. And, on test 3 items she was again found to be better than the groups and R.C. as she was considerably faster at finding the concealed word. By comparison with the control groups, and M.B. R.C. was in general slower across all 3 test types, particularly test types 2 and 3. Thus these results suggest that R.C. suffers from a more global orthographic segmentation deficit than M.B. whose difficulties are restricted to test 2 items (e.g. "some"). (See graph for these results.)

5. Spelling: Regular and Irregular Words

The data pertaining to the performances of the 2 groups and cases concerning accuracy, and type of spelling error are presented in Tables 28 and 29 respectively.

TABLE 28

Mean Percentage Correct Spelling: Regular and Irregular Words

	Regular		Irregular	
	high frq	low frq	high frq	low frq
Reading age controls	41.3	39.0	23.3	15.8
Poor reader group	39.0	29.7	22.4	16.0
M.B.	27.0	20.0	20.0	7.0
R.C.	7.0	0.0	7.0	7.0

Discussion

In the previous analysis (see chapter 7) both groups were found to be significantly more accurate on the regular words compared with the irregular words. By contrast, we can see from Table 28 above that the 2 cases are not like this i.e. they tend to perform about as well on the irregular words as the regular words. M.B., the more accurate speller of the 2 cases, does however show a small spelling regularity effect, whereas R.C. is in fact more accurate on the irregular words. Another aspect of the results worthy of note concerns the poor accuracy of the 2 cases overall: the mean spelling age of the poor reader group was 7.4 compared with M.B.'s spelling age of 7.0 and R.C.'s of 5.9, and so imperfect matching may be responsible for these differences.

Type of Spelling Error

By reference to Table 29 the groups and the 2 cases' scores as regards phonetic accuracy can be seen.

TABLE 29

Mean Percentage of Phonetically Inaccurate Spelling Errors

	Regular Words high frq	Regular Words low frq	Irregular Words high frq	Irregular Words low frq
Reading age controls	40.5	56.2	29.8	22.5
Poor reader group	52.6	66.8	34.4	35.5
M.B.	56.0	75.0	58.0	43.0
R.C.	86.0	66.0	100.0	71.0

Discussion

In the analysis given earlier in this thesis (see chapter 7) the poor reader group were found to make significantly more non-phonetic spelling errors than their controls. A similar trend is found among the 2 cases, which as far as R.C. is concerned, is considerably more striking. Thus while the poor reader group makes more non-phonetic errors than their controls the cases make yet more non-phonetic errors than even the poor reader group.

6. Phonemic Segmentation - Odd Word Out

The data pertaining to the performance of the groups and the cases can be found in Table 30.

TABLE 30

Percentage Correct in Odd Word Out Task

	Initial Phoneme	Middle Phoneme	Final Phoneme
Reading age controls	43.9	75.5	84.0
Poor reader group	51.9	57.3	65.6
M.B.	16.0	66.0	66.0
R.C.	33.0	33.0	33.0

Discussion

In the previous analysis (see chapter 7) the poor readers were found to be impaired relative to their controls on those trials where the phonemes differed in their middle and final positions (see Table 30). In other words on list type 2 (e.g. dot, cot, pot, bat), and on list type 3 (e.g. hat, sat, pat, bad) respectively, but not on list type 1 initial phoneme items (e.g. pad, man, mat, mad). M.B. is very much worse than the poor reader group on initial phoneme items, but similar to them on the other 2 types of item. By contrast, R.C. shows the same pattern of performance on each type and is clearly worse than the poor reader group overall. R.C. is also therefore worse compared with M.B. on the middle and final phoneme items.

General Discussion

The results of the research reported in this chapter are relevant to two main issues, one involving the processes that underlie "phonological" dyslexia (and dysgraphia), the other involving the extent to which poor readers who are defined in these terms are typical of the general population of children with reading (and spelling) disorders. The first issue will be addressed in the course of examining the results of the children on tasks 1 to 6, and then an answer to the second (related) issue will be proposed.

Firstly in contrast to the poor reader group, who did show a regularity effect (see task 1), the 2 cases were largely uninfluenced by spelling-to-sound irregularity, and in R.C.'s case there was no effect whatsoever of this variable on her performance. Further evidence for a "logographic" reading style was found in connection with the errors the children made on attempting to read the words in task 1: both cases made more lexicalisation responses than the poor reader group; as regards neologistic errors R.C. made very few of these compared with the poor reader group and M.B. made none at all. In line with a logographic characterisation of these 2 girls' approach to print was the additional finding that neither case made any regularisation errors whereas the poor reader group made a substantial number. In lexical decision (task 2) a similar picture is found: that is, unlike the poor reader group, who did exhibit a significant effect of pseudohomophony, the 2 cases were either basically insensitive to the phonological features of the non-words (M.B. showed only a very marginal effect), or totally insensitive to these features (R.C. was actually more accurate on the pseudohomophones).

The 2 cases' severe difficulties in using grapheme-to-phoneme rules were further highlighted in connection with their performances on the non-word naming tasks (see task 3 (i) and (ii): compared with the group of poor readers, both cases were extremely poor at reading the more complex non-words (i.e. task 3 (i) items); they were also impaired at naming the simple non-words which in the case of R.C. was dramatic compared with the poor reader group. As regards their errors on these non-words while both girls made somewhat more lexicalisations than the poor reader group on the more complex non-words, the striking difference occurred on the neologistic errors with R.C. making none whatsoever compared with the poor reader group and M.B. On the simple non-words both cases made considerably more lexicalisation errors than the poor reader group, but a similar number of neologistic type responses. The fact that R.C. (the more prototypical "phonological" dyslexic of the cases) was able to engage in some grapheme-to-phoneme processing in trying to name the simple non-words, as evidenced by her large number of neologisms on these items, suggests that she possesses some rudimentary phonic skills. Indeed M.B. may have behaved more like R.C. on all the reading tasks if she had not received remedial help which stressed a phonic approach. Seymour and McGregor (1984) argue that reading development in phonological dyslexia proceeds along logographic lines with words being acquired by the lexicon as "whole units" i.e. without attention to their spelling-to-sound structures. This characterisation would seem to fit the 2 cases, whose reading strategies tend not to exploit the phonological information in print. Also, given M.B.'s slow rate of reading development as reflected in the lack of change in her B.A.S. reading age over a long period, it suggests that when reading development is mediated in this manner it proceeds at an abnormally slow rate. Of course it is possible that M.B.'s very poor visual memory (for her chronological age) contributed to her virtual lack of progress since a logographic approach may make greater demands upon visual memory than a phonological approach (see Table 16 for details of her visual sequential memory score).

In order to examine in more detail their non-word reading deficiencies the poor reader group and both cases received an orthographic segmentation task. Traditional lexical analogy models of reading stress the importance of orthographic segmentation (see chapter 1 and the discussion of these models), thus it would seem reasonable in terms of such an approach to expect that a child who had serious non-word reading difficulties would also exhibit impairments at segmenting orthographic structure. However, the poor reader group, who did have non-word reading difficulties compared with their reading age controls, were found to have normal segmentation skills for their reading age. Therefore as far as the segmentation processes engaged by the present task are concerned it would seem unwarranted to link their non-word deficiencies with a segmentation deficit. Since Funnell (1983) also failed to detect segmentation difficulties in her case of phonological dyslexia she concluded that her results were more readily interpreted via a dual route account, and others (e.g. Temple, 1985; Coltheart, 1985) have agreed with her argument. It is important to note however that the ability to conduct segmentation effectively is also necessary with respect to certain recent conceptions of the non-lexical reading route and for this reason Funnell's preference for a dual route account of non-word naming should not be taken to suggest that visual segmentation is irrelevant to reading via a non-lexical mechanism. For example, in connection with R.C.'s weak segmentation skills, these may be accounted for in terms of the proposals advanced by Shallice and Warrington (1983): according to these authors spelling-to-sound rules operate at a variety of sublexical levels and so the ability to read non-words at a level appropriate for one's reading age may require the ability to utilise the most appropriate level of segmentation. R.C. may have had difficulty in detecting the correct (i.e. optimal) levels of analysis.

Such an interpretation would not appear to illuminate M.B.'s non-word reading difficulties since her segmentation skills seemed excellent. Her main difference from the group of poor readers arose in connection with test type 2 (e.g. "some") and as these were the only items she found problematic an explanation is required. Since the phonology of the parent word containing these items differs from that of its segments a conflict arises when the phonology of these segments has to be produced in isolation from the parent member. Thus in order to respond correctly the child must actively suppress the phonology of the parent word. M.B. was observed to have difficulty in doing just this.

Such "phonological conflict" is far less of a problem with test types 1 and 3 since in the case of test type 1 items (eg. piglet) the sounds of the segments do not differ from their sounds when combined in the parent word. Equally, in test 3 items the task is to identify the concealed word, a "pure segmentation" task, and so the question of conflict does not arise. It follows from this brief account of M.B.'s performance that even her relatively weak performance on test 2 items does not necessarily indicate a visual segmentation deficiency, and may instead be associated with a speech related phonological disability.

As regards the 2 girls' spelling retardation their performance on the experimental tasks suggested that they had difficulty in using the phonological spelling routine. The group of poor readers exhibited significant spelling regularity effects whereas only M.B. showed a very marginal effect of regularity (i.e. M.B. was slightly more accurate on the regular words). There are problems however in drawing firm conclusions about the status of R.C.'s spelling strategy since she was well behind the group in her spelling age. It is however warranted to conclude that both M.B. and especially R.C. have difficulties in using phoneme-to-grapheme rules to spell since they make more non-phonetic spelling errors compared with the poor reader group. Such errors are unlikely to be a product of a low spelling age since very young children tend to make phonologically meaningful errors when required to spell unknown words (see e.g. Read, 1971, 1975). And for this reason these errors in both cases may be reflecting genuine phonological impairments.

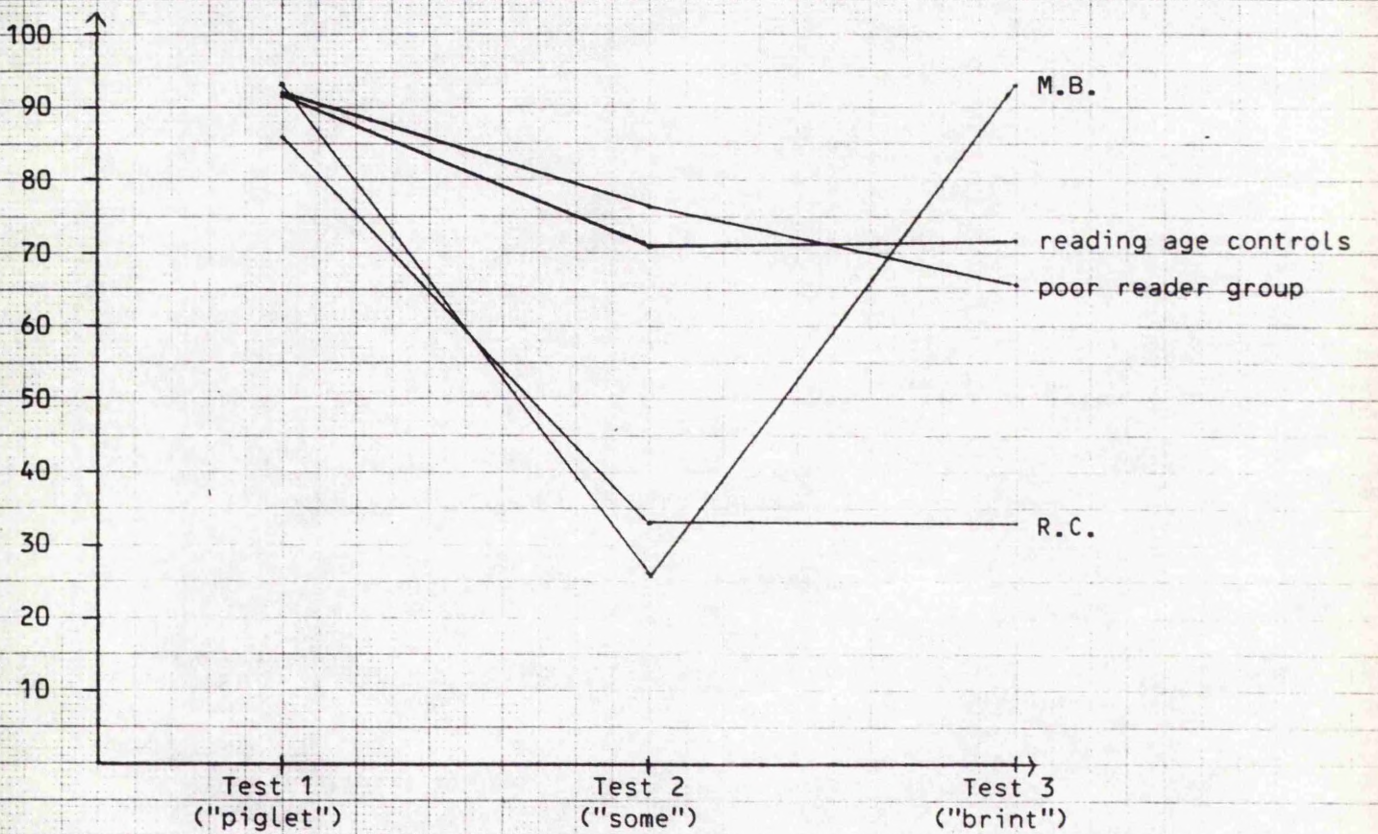
Indeed evidence of phonemic segmentation difficulties was found in connection with the 2 girls performance on the odd word out task (i.e. task 6). In addition to being worse overall compared with the group of poor readers (but not M.B. as far as initial phoneme lists were concerned) R.C. also had a poor score on the Sound Blending test (see Table 16). Thus both her blending and segmentation skills were deficient compared with M.B., whose Sound Blending score was some 2 years superior. It is also interesting to note the close association between both girls' spelling ages and their performance on the test of Sound Blending since this suggests that they are dependent upon similar underlying mechanisms.

Clearly both girls experience difficulties in utilising phonological information across a wide range of tasks involving reading and spelling. In the light of the preceding discussion it would therefore seem reasonable to categorise them as developmental phonological dyslexics (and dysgraphics). The drawback of such a characterisation of their literacy disorders is that it is misleading in important ways. First, since these 2 girls were also poor at naming words (see task 1) as well as non-words they do not exhibit the kind of discrepancy which is at the core of the diagnosis of acquired phonological dyslexia (i.e. poor non-word relative to good word reading ability). Secondly, it was found that both girls were different from each other in terms of the severity of their literacy disorders as well as in how the underlying components of these may be casually related to one another. Thus in these young children the aetiology of the phonological impairments involving reading and spelling may differ in subtle ways, and by simply classifying them as phonological dyslexics (or dysgraphics) we exaggerate the extent to which their disorders are like those of adult patients. In other words, this approach would tend to ignore, as Frith (1985) argues, the developmental context of childhood disorders, and how children who share certain overt behaviours may be qualitatively different in terms of the underlying mechanisms which are responsible for their surface similarities. A moral which should be drawn from this is that while it may be of theoretical interest to detect features of acquired dyslexic/dysgraphic literacy styles in children the sources of these "symptoms" in children may be radically different from those in adults. For this reason researchers should avoid viewing these symptoms uncritically and instead regard them as approximate indicators to be probed further in a genuinely individually orientated examination which takes into account the fact that the child is in the process of acquiring linguistic skills.

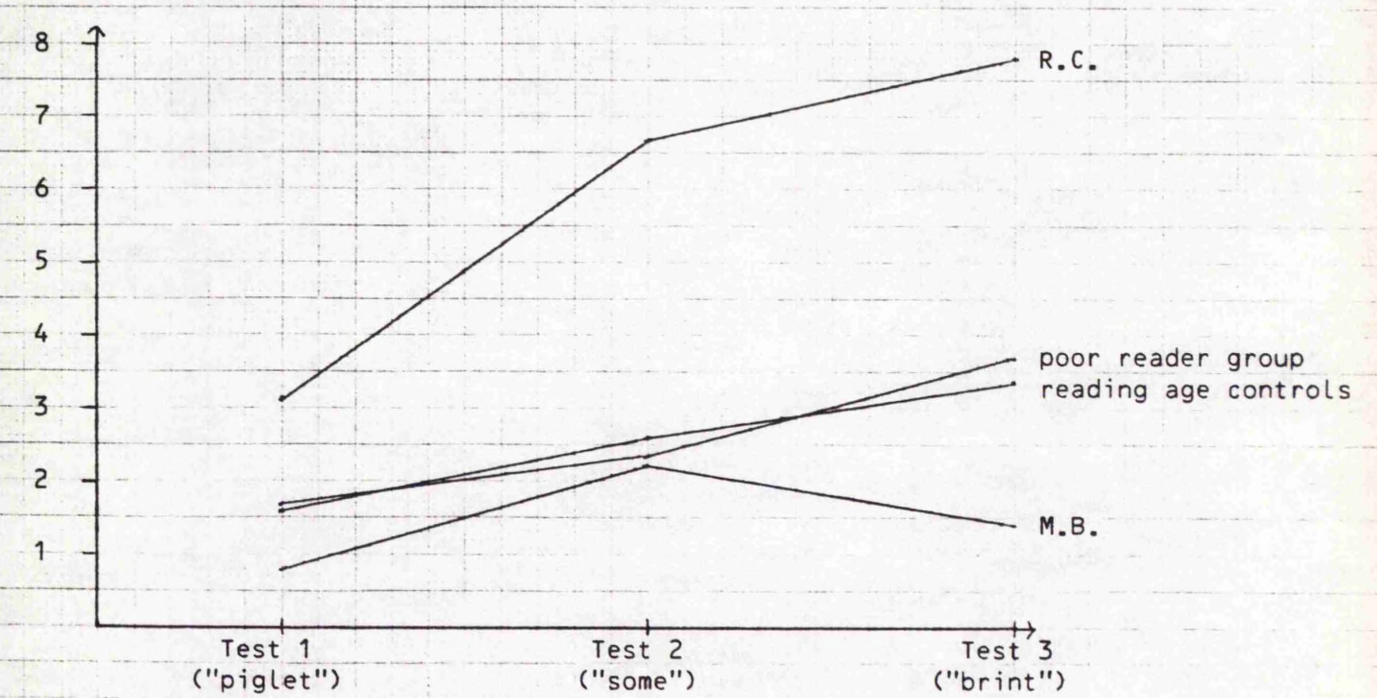
Finally, contrary to Temple's (1985) speculation that "developmental phonological dyslexia accounts for a substantial proportion of children with developmental dyslexia" (p. 526) the research reported in this chapter suggests that most poor readers are able to use a phonological approach successfully in many reading situations. However, there are a few poor readers whose phonological reading deficit is sufficiently severe to merit comparison with acquired phonological dyslexia/dysgraphia and to this extent Temple's view is only applicable to the 2 cases described in this chapter.

ORTHOGRAPHIC SEGMENTATION TASK

(i) ACCURACY (mean percentage correct)



(i) LATENCY (mean reaction time)



CHAPTER 9

The aim of the 7 experiments concerned with memory codes reported in the 2 sections of this chapter is to contribute to our understanding of the memory difficulties which are associated with literacy disorders in children. In chapter 4 of this thesis the literature concerned with memory coding in these children was reviewed and its limitations outlined. Since the reading difficulties as well as the spelling difficulties shown by these children may be connected with more fundamental deficits involving short and long term memory it is essential to examine their performance in memory tasks in order to acquire a more adequate grasp of the underlying causes of their retardation (see Wagner and Torgeson, 1987). To explore the nature of their memory capabilities 2 different experimental paradigms are used here, tests of short-term memory (i.e. working memory) and tests of longer term memory (i.e. recognition memory). By employing both paradigms it is possible to provide a more detailed characterisation of their weaknesses. One of the main drawbacks of previous research has been its reliance upon tasks which either examine working memory or long-term memory in isolation from one another, and as was noted in chapter 4 this methodological approach has left certain key issues unresolved. The questions which are addressed in this chapter will be briefly outlined again for convenience

- a more comprehensive account of the issues examined in this chapter are discussed in chapter 4.

Shankweiler et al. (1979) discovered reduced phonological similarity effects in their 8 year old poor readers compared with chronological age controls. Other studies confirmed their results on poor readers of a similar age (e.g. Mann et al., 1980; Siegal and Linder, 1984). However, Johnston (1982) failed to replicate these results on poor readers aged 9, 12 and 14, which suggests that their deficit connected with using a phonological code in working memory is overcome with age and limited to 8 year old poor readers. Conflicting evidence however was provided by Hall et al. (1983) who, contrary to the findings of some studies reporting impairments in poor younger reader's working memory, found that even 8 year old poor readers exhibit normal effects of phonological similarity. The difficulty connected with accepting the findings of Hall et al. (1983) concerns the representativeness of their poor reader sample. Unlike other poor reader samples they did not show reduced memory spans compared with chronological age controls and for this reason they would appear to by atypical of the general population of poor readers. A further shortcoming of existing research in this area was its failure to take into account the shorter spans of poor readers when designing the experimental trials. This flaw is clearly illustrated in connection with the behaviour of the low ability poor readers studied by Hall et al. (1983): these poor readers showed normal phonological similarity effects when recalling 4 item lists, but not when recalling 5 item lists. Thus task difficulty may have been greater for the poor readers in previous studies (e.g. Shankweiler et al., 1979) and this could have prevented the critical interaction between item type and recall from emerging. Johnston et al. (1987b) controlled for task difficulty, and found normal effects of phonological similarity in their 8 and 11 year old poor readers. Their findings strongly support the view that the failure of much previous research to find normal effects of phonological similarity in 8 year old poor readers is due to an experimental artifact associated with task difficulty.

The results of studies dealing with longer-term memory in poor readers have provided a more coherent picture: Mark et al. (1977) found that their poor readers were significantly less prone to make false-positive responses to rhyming distractors than controls. Bryne and Shea (1979) replicated their results and also found a tendency among their poor readers to select more of the semantic distractors. It is unclear however whether these poor readers difficulties connected with using a phonological code in longer-term memory is limited to 8 year old (poor readers) since Olson et al. (1984) could only replicate their results on their younger 8 year old group of poor readers. However, a very recent study by Rack (1985) suggests that this is not true since he found that much older 12/13 year old poor readers showed signs of relying upon a visual-orthographic rather than phonological memory code compared with reading age controls. In Rack's study a cued-recall recognition memory procedure was used to examine memory coding in both the visual and auditory modalities. In the initial phase of his experiments the children were required to judge whether 2 words rhymed; these words were visually presented in the test of visual recognition memory and auditorily in the test of auditory recognition memory. As far as test of visual recognition memory was concerned this was then followed by one item from the pair being shown to the child to help cue the recall of the other pair member. The poor readers were found to be better at remembering targets cued by items which were orthographically similar to the target (i.e. "lost" cued by "post") than reading age controls whose performance was more facilitated by phonological similarity (i.e. "air" cued by "dare") between cue and target. In the auditory version of this experiment somewhat weaker evidence of differential memory coding was found. In this task the cues and targets were read aloud to the children; the performance of the poor readers was found to be more facilitated by orthographic similarity than their reading age controls.

The first 4 experiments described in this chapter are aimed at trying to replicate Rack's pattern of results on younger 8 and 11 year old poor readers. In these experiments a recognition memory paradigm is employed. If these younger children behave like Rack's poor readers it would suggest that their abnormal memory coding was a stable feature of their cognitive development which accompanies them throughout their primary school education.

In the subsequent experiments (i.e. 10 and 11) the performance of another sample of 8 year old poor readers is evaluated on tests of working memory and longer term visual recognition memory.

SECTION 1

EXPERIMENT 8(a) - VISUAL RECOGNITION MEMORY AND RHYME JUDGEMENT - 8 YEAR OLDS

Method

Subjects

These were the 8 year old poor readers described in chapter 5 of this thesis and their reading age controls. It was also possible to use as a chronological age control group the reading age controls for the 11 year old poor readers since these were similar in chronological age to the 8 year old poor readers. For details of these 3 groups reading ages, chronological ages and I.Q.'s see Table 31.

Materials

(a) Rhyme Judgement Task

The stimuli consisted of 64 word pairs, categorised into 4 types, orthographic and phonological similarity being varied orthogonally (see Appendix 9). These 4 types were:

Type 1

These were orthographically dissimilar rhyming word pairs e.g. "food rude" (mean frequency 205 (S.D. 341), and 201 (S.D. 297) respectively, according to Carroll, Davies and Richman (1971), Grade 3 norms).

Type 2

These were orthographically similar rhyming word pairs e.g. "town down" (mean frequency 275 (S.D. 361), and 162 (S.D. 369) respectively).

Type 3

These were orthographically dissimilar non-rhyming word pairs e.g. "boil safe" (mean frequency 247 (S.D. 214), and 205 (S.D. 219) respectively).

Type 4

These were orthographically similar non-rhyming word pairs e.g. "post lost" (mean frequency 146 (S.D. 209), and 175 (S.D. 298) respectively).

(b) Recognition Memory Task

Condition A - recognition memory for orthographically similar pairs e.g. 'post-lost'

Twelve pairs of words were taken from the Type 4 pairs in the rhyme judgement task, these items being orthographically similar but non-rhyming; these constituted the cue and target items. Three other items were presented as distractors. One of these was a foil word which rhymed with the cue, but was orthographically dissimilar, and the other 2 distractors were unrelated. Thus a child was shown 'post' as the cue, 'lost' as the target, and 'toast' as the foil; 'fail' and 'each' were the unrelated distractors (see Appendix 10).

Condition B - recognition memory for rhyming pairs e.g. "food-rude"

Seven pairs of words were selected from the Type 1 list, these pairs being orthographically dissimilar but rhyming. The first item constituted the cue and the second item constituted the target. Three other items formed the distractors. Of these, one was a foil item, orthographically similar to the cue, but not rhyming with it. Thus a child was shown "food" as the cue, 'rude' as the target, and 'hood' as the foil; 'puff' and 'torn' were the unrelated distractors (see Appendix 10).

Procedure

(a) Rhyme Judgement Task

the word pairs were randomised and presented successively in lower-case on the monitor of a microcomputer. The first item remained on the screen for one second, the screen being blank for one second until the appearance of the second word; this item remained on the screen until the child made a response by pressing a "yes" or a "no" button interfaced with the computer. The children were told to respond as quickly and as accurately as possible.

(b) Recognition Memory Task

Immediately after the rhyme judgement task the children were asked to carry out the recognition memory task; they were not given prior warning of the second phase of the experiment. The cue item was shown to the child by being placed face up on the desk in front of the child. The 4 other items were randomised, shown to the child one at a time and placed face up on the desk beside the cue item. The children were asked not to make a choice until all the cards has been presented. All 19 sets were randomised before testing, so that the conditions were not presented in blocks.

Results

(a) Visual Rhyme Judgement Task - 8 Year Olds

The mean number of items correct was calculated for the 4 word pair types. A 3 way analysis of variance was carried out on these data. There was one between subjects factor: groups (poor readers, reading age and chronological age controls), and 2 within subjects factors: rhyme (rhyming versus non-rhyming word pairs) and similarity (orthographically similar versus dissimilar word pairs). See Table 32 for the means and standard deviations.

The poor readers were worse overall at rhyme judgement than both control groups, $F(2, 57) = 50.45$, $p < .0001$. There was also a main effect of rhyme, $F(1,57) = 32.58$, $p < .00001$, and similarity, $F(1,57) = 89.22$, $p < .0001$. These factors also interacted, $F(1,57) = 225.91$, $p < .00001$. However, there was a 3 way interaction between groups, rhyme and similarity, $F(2,57) = 3.3$, $p < .05$, so the data will be described at this level. Newman Keuls tests showed that all 3 groups were less accurate in responding to Type 1 pairs (e.g. "food-rude") than to Type 2 rhyming controls (e.g. "town-down"). Also, the 3 groups made fewer accurate responses to Type 4 pairs (e.g. "post-lost") than to Type 3 (e.g. "boil-safe") non-rhyming controls.

Results

(b) Visual Recognition Memory Task - 8 Year Olds

The mean proportion correct choices were calculated for each subject, as were the responses to the foils and the 2 distractors. The means and standard deviations are to be found in Table 33.

A 3 way analysis of variance was carried out on correct and foil choices. There was one between subjects factor: groups (poor readers, reading age and chronological age controls), and 2 within subjects factors: response category (correct or foil choice) and conditions (A and B).

The performance of the 3 groups overall was not found to differ, $F < .01$. However, there was a main effect of conditions, $F(1,57) = 9.59$, $p < .003$, and response categories, $F(1,57) = 56.36$, $p < .00001$; these factors also interacted $F(1.57) = 14.95$, $p < .0003$. There was also a 2 way interaction between groups and response categories, $F(1,57) = 3.77$, $p < .03$. However, there was also a 3 way interaction between groups, conditions and response categories, $F(2,57) = 5.95$, $p < .005$, so the data will be described at this level. Newman Keuls tests showed that the poor readers made fewer correct responses to Condition B pairs (e.g. "food-rude") than the reading age and chronological age control groups. However, the poor readers made a similar number of correct responses as the 2 control groups to Condition A pairs (e.g. "post-lost"). As far as foil choices were concerned, the poor readers were more likely to choose orthographically similar foils on Condition B pairs (e.g. "hood" cued by "food") than both control groups, but on Condition A pairs they choose a similar number of rhyming foils as the 2 control groups (e.g. "toast" cued by "post").

EXPERIMENT 8(b) - VISUAL RECOGNITION MEMORY AND RHYME JUDGEMENT - 11 YEAR OLDS

Method

Subjects

These were the 11 year old poor readers described in chapter 5 of this thesis and their reading age and chronological age controls. For details of these 3 groups reading ages, chronological ages and I.Q.'s see Table 34.

Materials

These were the same as those that were used in the previous experiment.

Procedure

This was identical to that used in the previous experiment.

Results

(a) Visual Rhyme Judgement Task - 11 Year Olds

The mean number of items correct was calculated for the 4 word pair types. A 3 way analysis of variance was carried out on these data. There was one between subjects factor: groups (poor readers, reading age and chronological age controls), and 2 within subjects factors: rhyme (rhyming versus non-rhyming word pairs) and similarity (orthographically similar versus dissimilar word pairs). See Table 35 for the means and standard deviations.

There were main effects of groups, $F(2,57) = 50.55$, $p < .0001$, rhyme, $F(1,57) = 21.44$, $p < .0001$, and similarity, $F(1,57) = 101.36$, $p < .0001$. However, these were modified by a number of interactions; there was a 2 way interaction between rhyme and similarity, $F(1,57) = 280.43$, $p < .0001$, but there was also a 3 way interaction between groups, rhyme and similarity, $F(2,57) = 13,28$, $p < .0001$, so the data will be described at this level. Newman Keuls tests showed that all 3 groups were less accurate in responding to Type 1 pairs (e.g. "food-rude") than to Type 2 rhyming controls (e.g. "town-down"). Also, all 3 groups made fewer correct responses to Type 4 pairs (e.g. "post-lost") than to Type 3 (e.g. "boil-safe") non-rhyming controls. Between group comparisons showed that the poor readers were as accurate as reading age controls on Type 3 pairs (e.g. "boil-safe"), but worse on the other pair types. The reading age controls responded equally well to all pair types except Type 4 (e.g. "post-lost") compared to chronological age controls.

Results

(b) Visual Recognition Memory Task - 11 Year Olds

The mean proportion correct choices were calculated for each subject, as were the responses to the foils and the 2 distractors. The means and standard deviations are to be found in Table 36.

A 3 way analysis of variance was carried out on correct and foil choices. There was one between subjects factor: groups (poor readers, reading age and chronological age controls), and 2 within subjects factors: response category: (correct or foil choice) and conditions (A and B).

The performance of the 3 groups was not found to differ overall, $F < .1$. However, there were main effects of conditions, $F(1,57) = 5.44$, $p < .03$, and response categories, $F(1,57) = 116.81$, $p < .0001$. There was also a 2 way interaction between groups and response categories, $F(2,57) = 5.33$, $p < .008$, and conditions and response categories, $F(1,57) = 10.73$, $p < .002$. There was also a 3 way interaction between groups, conditions and response categories, $F(2,57) = 4.69$, $p < .02$, and so the data will be described at this level. Newman Keuls tests showed the poor readers made fewer correct choices to Condition B pairs (e.g. "food-rude") than both control groups, who did not differ from each other. With Condition A pairs (e.g. "post-lost") the poor readers were superior to reading age controls, but worse than chronological age controls. As far as foil choices were concerned, the poor readers were more likely to choose orthographically similar foils in Condition B (e.g. "hood" cued by "food") than both control groups. In Condition A pairs (e.g. "post-lost") the poor readers made fewer rhyming foil choices than reading age controls (e.g. "toast" cued by "post"). However, compared with chronological age control the poor readers made a similar number of rhyming choices in Condition A.

EXPERIMENT 9(a) - AUDITORY RECOGNITION MEMORY AND RHYME JUDGEMENT - 8 YEAR OLDS

Method

Subjects

These were the same children who took part in experiment 8(a).

Materials

(a) Rhyme Judgement Task

The stimuli consisted of a different set of the 4 types of word pair from those used in experiments 8(a). As before these consisted of 64 word pairs, categorised into 4 types, orthographic and phonological similarity being varied orthogonally (see Appendix 11). These 4 types were:

Type 1

Orthographically dissimilar rhyming word pairs (e.g. "word bird" (mean frequency 191 (S.D. 322) and 199 (S.D.

454) respectively, according to Carroll, Davies and Richman (1971), grade 3 norms).

Type 2

These were orthographically similar rhyming word pairs (e.g. "rice mice") (mean frequency 218 (S.D. 344) and 212 (S.D. 367) respectively).

Type 3

There were orthographically dissimilar non-rhyming word pairs (e.g. "twin dish") (mean frequency 195 (S.D. 221) and 188 (S.D. 241) respectively).

Type 4

These were orthographically similar non-rhyming word pairs (e.g. "leaf deaf") (mean frequency 168 (S.D. 289) and 180 (S.D. 265) respectively).

(b) Recognition Memory Task

Condition A - recognition memory for orthographically similar pairs e.g. "leaf-deaf"

Twelve pairs of words were taken from Type 4 pairs in the rhyme judgement task, these items being orthographically similar but non-rhyming; these constituted the cue and the target items. Three other items were presented as distractors. One of these was a foil word which rhymed with the cue, but was orthographically dissimilar, and the other 2 distractors were unrelated. Thus a child was shown "leaf" as the cue, "deaf" as the target, and "beef" as the foil; "lick" and "goat" were the unrelated distractors (see Appendix 12).

Condition B recognition memory for rhyming pairs e.g. "word-bird"

Seven pairs of words were selected from the Type 1 list, these pairs being orthographically dissimilar but rhyming. The first item constituted the cue and the second item the target. Three other items formed the distractors. Of these, one was a foil item, orthographically similar to the cue, but not rhyming with it. Thus a child was shown "word" as the cue, "bird" as the target, and "lord" as the foil; "heap" and "lark" were the unrelated distractors (see Appendix 12).

Procedure

(a) Rhyme Judgement Task

The word pairs were randomised and presented through a cassette recorder which was controlled by a microcomputer. There was a one second gap between each member of word pair. The children were asked to respond as quickly and as accurately as possible. The child responding by pressing a "yes" or a "no" button interfaced with the computer.

(b) Recognition Memory Task

Immediately after the rhyme judgement task the child was asked to carry out the recognition memory task; they were not given prior warning of the second phase of the experiment. The cue item was read aloud to the child by the experimenter; the other 4 items were then read aloud also by the experimenter and the child was asked not to make a choice until he had heard all the 4 words. All 19 sets were randomised before testing,so that the conditions were not presented in blocks.

Results

(a) Auditory Rhyme Judgement Task - 8 Year Olds

The mean number of items correct was calculated for the 4 word pair types. A 3 way analysis of variance was carried out on these data. There was one between subjects factor: groups (poor readers, reading age and chronological age controls), and 2 within subjects factors: rhyme (rhyming versus non-rhyming word pairs) and similarity (orthographically similar versus dissimilar word pairs). See Table 37 for the means and standard deviations.

There was a main effect of groups, $F(2,57) = 19.51$, $p < .00001$. Newman Keuls tests showed that the poor readers were worse overall at rhyme judgement than the 2 control groups. The performances of the 2 control groups were not found to differ. More accurate responses were made to rhyming pairs than to the non-rhyming pairs, ($F(1,57) = 4.12$, $p < .05$, and responses to Type 4 pairs (e.g. "leaf-deaf") were less accurate than responses to Type 3 pairs (e.g. "twin-dish"), $F(1,57) = 16.67$, $p < .0001$. However, rhyme and similarity also interacted, $F(1,57) =$

62.23, $p < .00001$. Newman Keuls tests showed that as far as rhyming pairs were concerned, responses were more accurate to Type 2 pairs (e.g. "rice-mice") than to Type 1 pairs (e.g. "word-bird"). As far as the non-rhyming items were concerned, responses were more accurate to Type 3 pairs (e.g. "twin-dish") than to Type 4 pairs (e.g. "leaf-deaf").

Results

(b) Auditory Recognition Memory Task - 8 Year Olds

The mean proportion correct choices were calculated for each subject, as were the responses to the foils and the 2 distractors. The means and standard deviations are to be found in Table 38.

A 3 way analysis of variance was carried out on correct and foil choices. There was one between subjects factor: groups (poor readers, reading age and chronological age controls), and 2 within subjects factors: response category (correct or foil choice) and conditions A and B).

There was no overall difference between the 3 groups, $F(2,57) = 1.19$, NS. However, there was a significant effect of response category, $F(1,57) = 433.59$, $p < .00001$, and a 2 way interaction between response categories and conditions, $F(1,57) = 33.16$, $p < .0001$, so that data will be described at this level. Newman Keuls tests showed that more correct choices were made to Condition B pairs (e.g.

"word-bird") than to Condition A pairs (e.g. "leaf-deaf"). As far as foil choices were concerned, more foil choices were made to Condition A items (e.g. "beef" cued by "leaf") than to Condition B items (e.g. "lord" cued by "word"). There was also a significant 2 way interaction between groups and response categories, $F(2,57) = 3.84$, $p < .03$. Newman Keuls tests showed that the poor readers made fewer correct choices than both control groups, but that the 3 groups did not differ in terms of their preference for particular foils. A 2 way interaction between groups and conditions was marginally non-significant $F(2,57) = 2.67$, $p < .08$, and $F < .1$ for the 3 way interaction between groups, conditions and response categories.

EXPERIMENT 9(b) - AUDITORY RECOGNITION MEMORY AND RHYME JUDGEMENT - 11 YEAR OLDS

Method

Subjects

These were the same children who took part in experiment 8(b).

Materials

(a) Rhyme judgement task

These were the same stimuli which were used in experiment 9(a).

(b) <u>Recognition memory task</u>

The 2 conditions (i.e. Condition A and B) were the same as those used in experiment 9(a) as were the stimuli.

Procedure

(a) <u>Rhyme judgement task</u>

This was the same as that used in experiment 9(a).

(b) <u>Recognition memory task</u>

This was the same as that used in experiment 9(a).

Results

(a) <u>Auditory rhyme judgement task - 11 year olds</u>

The mean number of items correct was calculated for the 4 word pair types. A 3 way analysis of variance was carried out on these data. There was one between subjects factor: groups (poor readers, reading age and chronological age controls), and 2 within subjects factors: rhyme (rhyming versus non-rhyming word pairs) and similarity (orthographically similar versus dissimilar word pairs). See Table 39 for the means and standard deviations.

There was a main effect of groups, $F(2,57) = 7.22$, $p < .002$. Newman Keuls tests showed that the poor readers were worse than the other 2 control groups overall; the performance of the 2 control groups however did not differ. There was a marginally non-significant effect of rhyme

($F(1,57) = 3.85$, $p < .055$ with performance being superior on the rhyming word pairs. Also, performance was more accurate on Type 3 pairs (e.g. "twin-dish") than on Type 4 pairs (e.g. "leaf-deaf"), $F(1,57) = 14.81$, $p < .0003$. However, rhyme and similarity also interacted, $F(1,57) = 72.87$, $p < .00001$. A Newman Keuls test showed that performance on Type 2 pairs (e.g. "rice-mice") was superior to that on Type 1 pairs (e.g. "word-bird"). However, on the non-rhyming word pairs performance was better on Type 3 pairs (e.g. "twin-dish") than on Type 4 pairs (e.g. "leaf-deaf").

Results

(a) Auditory recognition memory task - 11 year olds

The mean proportion correct choices were calculated for each subject, as were the responses to the foils and the 2 distractors. The means and standard deviations are to be found in Table 40.

A 3 way analysis of variance was carried out on correct and foil choices. There was one between subjects actor: groups (poor readers, reading age and chronological age controls), and 2 within subjects factors: response category (correct or foil choice) and conditions (A and B).

There were significant main effects of groups, $F(2,57) = 3.69$, $p < .03$, and response categories, $F(1,57) = 642.53$, $p < .0001$, but these factors also interacted, $F(1,57) = 8.68$, $p < .0005$. Newman Keuls tests showed that the poor readers and reading age controls were less accurate than the chronological age controls, but did not differ from each other. All 3 groups choose foil items to the same extent. There was a main effect of conditions, $F(1,57) = 5.44$, $p < .03$, but this interacted with response categories, $F(1,57) = 35.51$, $p < .0001$. Newman Keuls tests showed that this interaction was due to more correct choices being made to items in Condition B (e.g. "word-bird"), but more foil choices being made in Condition A (e.g. "beef" cued by "leaf"). The groups by conditions interaction did not reach significance, $F < .1$.

Summary and Discussion

In experiment 8(a) the 8 year old poor readers were found to be less accurate at rhyme judgement than controls. All groups behaved in a parallel manner on the word pair types: they tended to respond "yes" when the word pairs were orthographically similar (e.g. Type 2 "town-down" and Type 4 "post-lost"). This approach was successful on Type 2 pairs which do rhyme, but not on Type 4 pairs which do not rhyme. This strategy is reflected in their pattern of performance in relation to the other comparisons which can be made; for example, they were better on Type 2 pairs (e.g. "town-down") than on Type 1 pairs (e.g. "food-rude"). Conversely, on Type 4 pairs (e.g. "post-lost") whose orthography is misleading about whether they rhyme, they were worse than on Type 3 pairs (e.g. "boil-safe") whose orthography does not suggest the items rhyme.

As far as the results of the 8 year old poor readers performance on the task of visual recognition memory was concerned evidence of qualitative group differences in memory coding was found. For example, the poor readers were inferior to the controls at remembering an item matched to an orthographically dissimilar rhyming word (e.g. "food" - "rude"). However, they were not found to be worse than controls at remembering an item matched to an orthographically similar non-rhyming word (e.g. "post" - "lost"). The poor readers greater sensitivity to orthography rather than rhyme as a cue is also apparent in their foil choices: they were more prone to make false-positive choices to orthographically similar non-rhyming foils than the controls. Thus taken together these results suggest that the poor readers were depending more upon the visual-orthographic features of the stimuli rather than the phonological features compared with the controls.

In experiment 8(b) the 11 year old poor readers were also found to be worse than the controls at rhyme judgement which suggests that poor readers do not overcome their phonological disabilities with age as a developmental lag theory would predict. The children in older groups were similar to the groups of younger children in terms of the general pattern of their behaviour on the types of word pair. All groups were better on Type 2 rhyming pairs (e.g. "town-down") than on Type 1 rhyming pairs (e.g. "food-rude"). As far as performance on the non-rhyming word pairs was concerned, the groups were more accurate on Type 3 pairs (e.g. "boil-safe") than Type 4 pairs (e.g. "post-lost"). These results would appear to imply that these children adopt a "visual" approach to rhyme judgement (i.e. they assume that if 2 words look alike they rhyme). It is of interest that similar findings have been reported by Johnston and McDermott (1986) in relation to adults suggesting that the performance of these children does not indicate immaturity of reading skill, but rather a deeply held belief about how orthography represents phonology.

As far as these 11 year old poor readers performance on the test of visual recognition memory was concerned the results are similar in character to those found in connection with the 8 year old poor readers. The 11 year old poor readers were worse than controls at remembering items matched to an orthographically dissimilar rhyming word (e.g. "food" - "rude"). However, in contrast to the 8 year old poor readers these older poor readers were actually superior to the controls at remembering an item matched to an orthographically similar non-rhyming word (e.g. "post" - "lost"). This may indicate that with age the ability of these children to compensate for their phonological deficits improves with the corollary that they can employ a "visual" memory code more effectively.

However, they still perform at an inferior level for their age since they were not found to be better on Condition A items than their chronological age controls. As far as the foil choices were concerned a complementary picture emerges: the poor readers tended to choose more orthographically similar non-rhyming foils than the controls, and fewer rhyming foils than reading age controls.

In experiment 9(a) the 8 year old poor readers were found to be inferior to the controls at auditory rhyme judgement. All the groups were better at judging Type 2 pairs (e.g. "rice-mice") than Type 1 pairs (e.g. "word-bird"); they were also more accurate on Type 3 pairs (e.g. "twin-dish") than on the other non-rhyming Type 4 pairs (e.g. "leaf-deaf"). The 11 year old poor readers were also found to be worse than their controls at auditory rhyme judgement and all groups showed a very similar pattern of performance to the younger children on the Types of word pair. It is of interest that these 8 and 11 year old children displayed a similar pattern of performance in auditory rhyme judgement to fluent adult readers; for example, Seidenberg and Tanenhaus (1979) asked normal adult subjects to monitor lists of spoken words for one that rhymed with a given word (e.g. "tie"), and the targets were either orthographically similar (e.g. "pie") or different (e.g. "rye") from the specified word. Latencies to the orthographically similar rhymes were significantly shorter.

Similar results were found in a follow-up experiment where rhyme judgements were faster to "pie-tie" pairs than to "pie-rye" pairs. Also, when the 2 words were orthographically similar, but non-rhyming (e.g. "leaf-deaf") latencies were longer compared with items which were dissimilar orthographically and non-rhyming (see also Donnenwerth-Nolan, Tanenhaus and Seidenberg, 1981; Tanenhaus, Flanigan and Seidenberg, 1980; Jakimik, Cole and Rudnicky, 1985).

As in the present experiment (i.e. 9(a) and (b) Rack (1985) found that his older poor readers were worse at auditory rhyme judgement than their reading age controls. Rack also found that his poor readers showed longer latencies to orthographically dissimilar rhyming pairs (e.g. "word-bird") than to orthographically similar rhyming pairs (e.g. "rice-mice") whereas their reading age controls failed to exhibit this effect (termed an "orthographic effect" by Rack). He interpreted this result to indicate that the poor readers were relying more on orthographic information in rhyme judgement than their reading age controls due to their phonological deficiencies which were shown in their inferior performance at auditory rhyme judgement, and argued that the source of this weakness was connected with their inability to use a phonological code in working memory. Although the results of the present experiment (i.e. the auditory version) have also shown that poor readers are inferior to their reading age controls at rhyme judgement the results of the experiments have not replicated Rack's differential "orthographic effect". Instead the children in all groups were found to show "orthographic effects" which were remarkably similar to those shown by fluent adult readers in the studies mentioned above. Thus even in children a word's orthographic code becomes available in auditory word recognition and influences decisions about rhyme which (logically) could be made without recourse to how a word is spelt.

As far as auditory recognition memory is concerned the results from these experiments fail to replicate Rack's: he found that his poor readers were significantly better at remembering targets cued by orthographically similar words despite the fact that the presentation modality was auditory. No such beneficial effect of orthographic similarity influenced the recall of their reading age controls. In experiment 9(a) the 8 year old poor readers were not found to show these or similar effects; in that experiment all groups were better on Condition B items than on Condition A items suggesting that the children were all relying upon phonological information. Their foil choices presented a similar story: all groups were more prone to make false-positive choices to foils which sounded like the cue word. The older 11 year old poor readers were found to behave in a similar manner to the children in 8 year old groups in terms of recognition memory performance.

Clearly, the findings from the experiments using visual presentation of materials confirms the view that poor readers rely upon a visual-orthographic memory code whereas normal readers rely upon a phonological code. The fact that Rack's evidence for qualitative memory coding differences between poor readers and reading age controls was somewhat weaker in auditory compared to visual presentation coupled with the failure of the present study to find such effects suggests that the effect is not robust under these conditions. However, before firm conclusions can be drawn about the results of the experiments (8(a) and (b)) which are consistent with the idea of group differences in memory coding certain weaknesses in his design means that the results can be interpreted quite differently, and in a way which does not entail the involvement of memory processes.

An alternative view of these differential effects of memory coding found in connection with the visual recognition memory tasks could be that they reflect response biases which operate when the children were uncertain as to which choice to make, and as the poor readers were worse at rhyme judgement they may have tended to base their guesses upon orthographic rather than phonological information. The actual testing procedures may have accentuated this behaviour in the poor readers as the items were laid on the table in front of the child remaining there until a response was made. At no point during the recognition testing phase or the rhyme judgement task were the children made aware of the phonological aspect of the stimuli by the experimenter and this may also have, in some unknown way, influenced both their approach to the rhyme judgement phase of the experiment and the recognition memory phase. If the poor readers were less accustomed to relying upon phonological information anyway these features of the experiment could have helped to bring about the observed group differences in visual recognition memory.

A separate source of concern arises in connection with the 8 year old poor readers who were found to be less accurate on the regularity task than their reading age controls (see chapter 5). This result casts doubt upon the extent to which they can be regarded as representative of poor readers, and for this reason it would also seem imprudent to accept their performance on the recognition memory task as indicative of how other samples of poor readers would behave under these circumstances. The experiments reported in the next section of this chapter attempt to overcome these problems which have produced results whose theoretical interpretation (and generalisability) is problematical.

SECTION 2

The main motivation behind the experiments reported in this section is to re-examine the question of phonological memory coding deficiencies in 8 year old poor readers by comparing their performance on tests of short-term working memory, and longer-term visual recognition memory. The first experiment (i.e. 10) addresses the question of whether they can utilise a phonological code in working memory as well as reading age controls by administering 2 versions of the same working memory task - an "easy" version and a "difficult" version. If it is true that poor readers have failed to show normal effects of phonological similarity in working memory because of inappropriate levels of task difficulty (as Hall et al., 1983 suggest) then like the poor readers investigated by Johnston, Rugg and Scott (1987b) they should show normal effects when the task is adjusted to suit their memory spans, and marginal or no effects when the task is at an inappropriate level of difficulty (i.e. at supra span size). However, it could be argued that even if under these circumstances of increased task difficulty they failed to show the critical effect of phonological similarity this may well indicate abnormal cognitive functioning. For example, Bauer (1977) has found that poor readers have weak verbal rehearsal strategies and so if the poor readers in the present study exhibited no effect under high task difficulty conditions then this could be accounted for in terms of impaired verbal rehearsal strategies. Thus in order to demonstrate that this not the case with these poor readers it is necessary to show that normal readers would also behave in a similar manner under high task difficulty conditions.

Thus in the first experiment the second sample of 8 year old poor readers (see chapter 6) were compared with their reading age controls on tests of working memory. After having their spans individually determined (following the procedure of Johnston, Rugg and Scott, 1987b) these groups were then given (a) a phonological similarity task at an appropriate (i.e. within span) level of difficulty, and (b) the same task at an inappropriate difficulty level (i.e. supra-span). In the next experiment (i.e. 11) an attempt was made to replicate the results of experiment 8(a) and to improve upon aspects of the methodology used in that experiment. Thus in experiment 11 instead of being permitted to read the item silently during the rhyme judgement phase of the experiment they were required to read the items aloud. Also, during testing of visual recognition memory rather than the items being presented silently and all being laid out before the child they were read aloud by the experimenter, and then placed on top of one another.

EXPERIMENT 10 - PHONOLOGICAL SIMILARITY TASK

Method

Subjects

These are the same children that are described in chapter 6 of this thesis and consist of 8 year old poor readers and their reading age controls.

Procedure

The letters used in the experiment (b, c, d, g, h, k, l, p, q, r, s, t, v, w) were singly presented in lower case on the monitor of a microcomputer; subjects were asked to read them out loud in order to check that they were able to recognise the letters. No child had to be excluded on these grounds.

Practice

Four practice sets were used consisting of 3 letters in each string; none of these items was used in the main experiment. The letters appeared in sequential order in the centre of the screen, remaining there for one second. A one second gap separated the items. At the offset of the final letter in a string a flashing cursor appeared in the same location to indicate recall. Subjects were provided with answer booklets to write down the items; they were requested to write down the items in the order that they had seen them, leaving a space for any item they could not remember.

Determination of Memory Span

Each subject's memory span was then determined on the basis of performance on non-rhyming items. An ascending staircase procedure was used, starting with string lengths of 2 items. Correct recall of a string length led to the number of items being incremented by one of the next trial. Memory span was set at one item less than the length at which 2 consecutive errors had occurred.

Experimental Task

Each child received alternating trials of phonologically similar and dissimilar letters from the sets 'b, c, d, g, p, t, v' and 'h, k, l, g, r, s, w' respectively. There were 7 trials for each set, each letter appearing once in each serial position. Subjects wrote down the items in booklets, as for the practice trials. Two conditions were used:

(i) Easy condition, string length being appropriate for each subjects' memory span.

(ii) Hard condition, each child receiving string lengths 3 items longer than memory span.

The order of presentation was counterbalanced, such that half of the subjects received the easy task first, and half received the hard task first.

Results

Memory span

A one way analysis of variance was carried out on the span scores of the 2 groups of children. The reading age controls had significantly better memory spans than the poor readers, $F(1,38) = 6.90$, $p < .02$. See Table 41 for means and standard deviations.

Effects of phonological similarity

For each subject, the proportion of letters recalled correctly in the appropriate serial position was computed for both phonologically similar and dissimilar items (see Table 2). A 3-way analysis of variance was carried out on these data, there being 2 within subjects factors - (1) phonological similarity (similar and dissimilar sounding items) and (2) conditions (easy and hard). There was one between subjects factor - (3) groups (poor readers and reading age controls).

No significant difference was found between groups ($F < 1$). Performance was better in the easy condition, $F(1,38) = 213.36$, $p < .0001$, and dissimilar sounding items were better recalled than similar sounding ones, $F(1,38) = 38.20$, $p < .0001$. However, these effects were modified by an interaction between conditions and phonological similarity, $F(1,38) = 29.05$, $p < .0001$. Newman Keuls tests showed that in the easy version of the task, dissimilar sounding items were recalled better than similar sounding ones. However, in the hard version of the task, recall did not differ for the 2 item types. See Table 41 for means and standard deviations.

Discussion

These results confirm the findings of Hall et al. (1983) and Johnston et al. (1987b) that 8 year old poor readers can show normal effects of phonological similarity. However, it was also shown that when task difficulty is increased, neither poor readers nor their reading age controls show effects of phonological similarity.

EXPERIMENT 11 - VISUAL RECOGNITION MEMORY AND RHYME JUDGEMENT

Method

Subjects

These were the same children who took part in the previous experiment.

Materials

(a) Rhyme judgement task

These were the same stimuli that were used in experiments 8(a) and (b).

(b) Recognition memory task

These were the same stimuli that were used in experiments 8(a) and (b).

Procedure

(a) Rhyme judgement task

The word pairs were randomised and presented successively in lower case on the monitor of a microcomputer. The first item remained on the screen for one second, the screen being blank for one second until the appearance of the second word; this item remained on the screen until the child made a response. As each word appeared the child was asked to pronounce it, and if they got it wrong it was pronounced for them. This ensured that the children in both groups always generated the items' phonological codes, or were made aware of them prior to making a rhyme judgement.

(b) Recognition memory task

Immediately after the rhyme judgement task the child was asked to carry out the recognition memory task. The cue item was read aloud by the experimenter as it was shown to the child, and placed face up on the desk. The other 4 items were randomised, shown to the child, and read out loud one by one by the experimenter. Each item was placed face-up on top of the preceding card. The child were told not to make a choice until all the cards had been presented. If they were uncertain about the choice, they were permitted to sort through the set of cards before making a decision.

Results

(a) Rhyme judgement task

The mean number of items correct was calculated for the 4 word pair types. A 3 way analysis of variance was carried out on these data. There was one between subjects factor - groups (poor readers and reading age controls) and 2 within subjects factors, rhyme (rhyming versus non-rhyming word pairs) and similarity (orthographically similar versus dissimilar word pairs). See Table 42 for means and standard deviations.

The poor readers were worse overall at rhyme judgement than the reading age controls, $F(1,38) = 27.60$, $p < .0001$. Responses to dissimilar items were more accurate than to similar ones for all the children, $F(1,38) = 40.32$, $p < .0001$, but there was no main effect of rhyme, $F < 1$. However, rhyme and similarity also interacted, $F(1,38) = 109.92$, $p < .0001$. Newman Keuls tests showed that responses to Type 4 pairs (e.g. 'post-lost') were less accurate than to non-rhyming controls (i.e. Type 3 pairs, e.g. 'boil-safe'), and that responses to Type 1 pairs (e.g. 'food-rude') were less accurate than to rhyming controls (i.e. Type 2 pairs (e.g. 'town-down)). The interaction between groups and rhyme was not significant, $F(1,38) = 2.03$, NS, and $F < 1$ for all other effects.

Results

(b) Recognition memory task

The mean proportion correct choices were calculated for each subject, as were the responses to the foils and the 2 distractors. The means and standard deviations are to be found in Table 43.

A 3 way analysis of variance was carried out on correct and foil choices. There was one between subjects factor, groups (poor readers and reading age controls) and 2 within subjects factors, response category (correct or foil choice), and conditions (A and B).

There was a marginally non-significant difference between the groups, $F(1,38) = 3.40$, $p < .07$, favouring the reading age controls. There were significant main effects of conditions $F(1,38) = 12.33$, $p < .002$, and response categories, $F(1,38) = 45.86$, $p < .0001$, but these were modified by a significant 3 way interaction between groups, response categories and conditions, $F(1,38) = 47.15$, $p < .00001$. Newman Keuls tests showed that the reading age controls made more correct responses to condition B pairs (e.g. "food-rude") than the poor readers, but that the poor readers made more correct responses to condition A pairs (e.g. 'post-lost') than the controls. As far as foil choices were concerned, the poor readers were more likely to choose orthographically similar foils on condition B pairs than controls, who in turn chose more rhyming foils on condition A pairs than the poor readers.

GENERAL DISCUSSION

These experiments demonstrated the existence of normal phonological similarity effects in poor readers, in the context of impaired phonetic coding in longer-term recognition memory. In experiment 10 it was shown that poor readers exhibit normal effects of phonological similarity in working memory tasks when the level of difficulty is appropriate to their shorter memory spans. Thus when the task is made too difficult they no longer recall phonologically dissimilar items better than phonologically similar items. Thus by using a within subjects design it has been possible to verify directly the suggestion of Hall et al. (1983) that under these conditions phonological similarity effects are abolished. An examination of the data from previous studies which have found reduced phonological similarity effects in poor readers, shows that high levels of task difficulty were involved. In experiment 10 the recall levels of the poor readers were reduced to around 25% level in the difficult condition. Shankweiler et al.'s (1979) poor readers overall recall was also quite low, that is, 39.5% for dissimilar items, and 29% of similar items. This suggests that in these studies which report reduced phonological similarity effects in poor readers the task was at a difficult level for the poor readers, and this could have brought about floor effects. Additional support for this view comes from the performance of the reading age controls: under high task difficulty conditions they also failed to show an effect of phonological similarity on recall. For this reason it cannot be argued that the abolition of this effect in poor readers implies abnormal cognitive functioning. Salame and Baddeley (1986) found that fluent adult readers also fail to show phonological similarity effects under high task difficulty conditions. Their results provide further support for the view that the present sample of poor readers were behaving normally under these high task difficulty circumstances. Instead of trying to adopt a verbal rehearsal strategy in connection with the difficult task both groups may have switched to a visual rather than a phonological code behaving like younger normal children who do not rely upon phonological coding in working memory until the age of 5 (Conrad, 1971).

On the basis of the present evidence however it cannot be argued that the poor readers employed phonological processes in working memory as efficiently as their reading age controls. Two separate results are relevant to this point: first their memory spans were significantly shorter than that of their reading age controls, and secondly they (like the poor readers in Rack's auditory rhyme judgement task) were worse at rhyme judgement. Several studies have reported impaired memory spans in poor readers (see e.g. Rugel, 1974), and it is unclear why this should be so if it is not obviously related to their ability to use a phonological code in working memory. The consideration of other research may help us to elucidate the interpretation of the present results.

Their memory impairment could be connected with a slowness to name objects, pictures and colours which several authors have reported in poor readers (e.g. Spring and Capps, 1974; Spring, 1976; Denckla and Rudel, (1976). Speech rate and naming speed have been shown to be closely related to memory span and the development of short-term memory capacity (see e.g. Case, Kurland and Goldberg, 1982; Hulme, Thompson, Muir and Lawrence, 1984) thus it is not unreasonable to argue that the poor readers impaired memory spans may be intimately associated with the slow encoding and rehearsal of verbalisable stimuli (see also Mann, 1984; Spring and Perry, 1983; Torgesen and Houck, 1980, for further evidence of correlations between naming speed and memory span).

In the rhyme judgement phase of experiment 11 further evidence of deficient phonological processing in the poor readers was found which replicates the results of the other experiments in this chapter, and experiment 6 (see chapter 7) where they were found to be worse at phonemic segmentation than reading age controls. The pattern of their performance on the Types of word pair was very similar to that shown by the earlier sample of 8 and 11 year old poor readers (i.e. experiment 8(a) and (b)); both groups performed poorly when their was a conflict between rhyme and orthography. Thus they were all prone to respond "yes" if pairs of words were orthographically similar and "no" if they were orthographically dissimilar which led to increased errors on Type 4 pairs (e.g. "post-lost"), and Type 1 pairs (e.g. "rude-food").

The results of the recognition memory task are similar to those found in the previous experiments which used visual presentation, and for this reason experiment 11 can be regarded as replicating Rack's results (Experiment 1). Clear indications of visual-orthographic memory coding were found in the poor readers; they were better at remembering items matched to orthographically similar non-rhyming words (e.g. "post" - "lost"), than to items matched to orthographically dissimilar rhyming words (e.g. "food" - "rude"). By contrast, their reading age controls showed the reverse pattern of performance in Conditions A and B. The question arises as to whether these results are due to response biases despite the attempt to eliminate these via the modifications that were made in the testing and experimental procedures. It is unlikely that the poor readers were approaching the rhyme judgement task differently from controls since the phonological component of the task was brought to the attention of the children in both groups by ensuring the items were read aloud; also, if they were approaching it differently one would have expected them to differ from controls in terms of the pattern of their performance on the Types of word pair, whereas they were found to be no more sensitive to orthographic similarity than controls in rhyme judgement. Further support for this view that genuine group differences in memory coding were being detected in the experiment is the fact that Rack found similar effects using a cued-recall paradigm in which response biases are less likely to influence the outcome. Also, Rack did not find that his poor readers were worse than their reading age controls at visual rhyme judgement and yet he still found evidence of visual-orthographic memory coding in his poor readers. Thus it cannot be plausibily argued that the poor readers behaviour in the recognition test is to be accounted for in terms of their inferior performance during the rhyme judgement phase of the experiment.

Finally, the question arises as to why the poor readers exhibited effects of phonological similarity in working memory and impoverished phonological coding in longer-term memory (i.e. Experiments 10 and 11 respectively). In experiment 10 the poor readers may have been able to both generate and retain phonological information from print because the items were very familiar and the time period over which the material had to remain in phonological form relatively brief. However, in the recognition memory test phonological information had to be passively retained over a much longer time period and for this reason it is likely that long-term memory storage mechanisms were involved. The poor readers would appear to be less proficient at retaining information in a phonological form over longer time spans than controls given their tendency to respond to visual rather than the phonological aspects of the testing materials. One might speculate that their behaviour on the recognition memory task is diagnostic of a more pervasive difficulty in integrating orthographic with phonological information during the course of learning to read.

TABLE 31

Mean Reading Age, Chronological Age and I.Q.'s: Experiment 8(a)

	Reading Age	Chronological Age	I.Q.
Eight year old poor readers:	7.1 (4.08)	8.7 (5.22)	107.8 (10.76)
Reading age controls:	7.3 (5.18)	7.1 (3.19)	108.5 (8.72)
Chronological age controls:	8.6 (5.8)	8.4 (5.94)	106.4 (7.54)

@ SD in parentheses

TABLE 32

Mean Accuracy Scores (out of 16) for Rhyme Judgement Task (Experiment 8(a))

	Type 1 "food-rude"	Type 2 "town-down"	Type 3 "boil-safe"	Type 4 "post-lost"
Poor readers:	7.75 (2.93)	12.30 (2.38)	12.05 (2.52)	4.50 (2.74)
Reading age controls:	11.95 (2.35)	14.45 (1.60)	14.85 (1.08)	7.80 (3.36)
Chronological age controls:	13.05 (1.60)	14.70 (1.41)	15.30 (0.80)	8.95 (3.37)

@ SD in parentheses

TABLE 33

Mean Percentage Correct on Recognition Memory Task (Experiment 8 (a))

	Poor readers	Reading age controls	Chronological age controls
Condition A "post-lost"			
Correct (e.g. "lost")	51.7 (21.6)	48.3 (25.2)	45.8 (21.7)
Foil (e.g. "toast")	36.2 (20.6)	39.6 (25.9)	42.5 (24.2)
Distractors (e.g. "each")	10.4 (12.5)	9.2 (10.2)	6.3 (8.5)
Non-response	1.7 (5.1)	2.9 (5.9)	5.4 (13.9)
Condition B "food rude"			
Correct (e.g. "rude")	49.3 (19.4)	73.6 (17.5)	74.3 (13.6)
Foil (e.g. "hood")	41.4 (20.1)	20.0 (14.2)	19.3 (12.5)
Distractors (e.g. "torn")	9.3 (10.6)	5.7 (0.8)	2.9 (5.9)
Non-response	0	0.7 (3.1)	3.6 (7.9)

@ SD in parentheses

TABLE 34

Mean Reading Age, Chronological Age and I.Q.'s: Experiment 8(b)

	Reading age	Chronological age	I.Q.
Eleven year old poor readers:	8.4 (6.85)	11.8 (10.1)	105.7 (12.1)
Reading age controls:	8.6 (5.68)	8.4 (5.94)	106.4 (7.54)
Chronological age controls:	11.8 (8.99)	11.6 (8.0)	105.1 (9.19)

@ SD in parentheses

TABLE 35

Mean Accuracy Scores (out of 16) for Rhyme Judgement Task (Experiment 8(b))

	Type 1 "food-rude"	Type 2 "town-down"	Type 3 "boil-safe"	Type 4 "post-lost"
Poor readers:	9.75 (2.59)	13.35 (2.43)	14.25 (0.96)	5.75 (3.27)
Reading age controls:	13.05 (1.60)	14.70 (1.41)	15.30 (0.80)	8.95 (3.37)
Chronological age controls:	13.45 (1.91)	14.85 (0.87)	15.50 (0.88)	11.20 (1.64)

@ SD in parentheses

TABLE 36

Mean Percentage Correct on Recognition Memory Task (Experiment 8(b))

	Poor readers	Reading age controls	Chronological age controls
Condition A "post-lost"			
Correct (e.g. "lost")	54.2 (22.4)	45.8 (21.7)	66.3 (21.2)
Foil (e.g. "toast")	28.7 (16.3)	42.5 (24.2)	21.7 (17.6)
Distractors (e.g. "each")	10.5 (10.4)	6.3 (8.5)	8.7 (9.9)
Non-response	6.6 (12.5)	5.4 (13.9)	3.3 (6.8)
Condition B "food-rude"			
Correct (e.g. "rude")	59.3 (24.6)	74.3 (13.6)	73.6 (20.3)
Foil (e.g. "hood")	30.7 (20.9)	19.3 (12.5)	16.5 (17.5)
Distractors (e.g. "torn")	5.7 (9.7)	2.9 (5.9)	4.2 (13.1)
Non-response	4.3 (9.3)	3.6 (7.9)	5.7 (9.7)

@ SD in parentheses

TABLE 37

Mean Accuracy Scores (out of 16) for Rhyme Judgement Task (Experiment 9(a))

	Type 1 "word-bird"	Type 2 "rice-mice"	Type 3 "twin-dish"	Type 4 "leaf-deaf"
Poor readers:	12.0 (2.38)	13.1 (2.54)	13.60 (2.56)	10.65 (3.08)
Reading age controls:	13.90 (1.37)	15.05 (1.53)	14.85 (1.04)	12.45 (2.16)
Chronological age controls:	14.35 (0.67)	14.90 (1.16)	15.10 (1.48)	13.05 (1.73)

@ SD in parentheses

TABLE 38

Mean Percentage Correct on Recognition Memory Task (Experiment 9(a))

	Poor readers	Reading age controls	Chronological age controls
Condition A "leaf-deaf"			
Correct (e.g. "deaf")	50.4 (15.2)	59.6 (14.9)	55.8 (19.9)
Foil (e.g. "beef")	27.9 (16.7)	29.2 (16.6)	23.3 (13.9)
Distractors (e.g. "lick")	16.3 (13.6)	6.2 (7.0)	8.7 (9.9)
Non-response	5.4 (8.4)	5.0 (7.3)	12.2 (6.5)
Condition B "word-bird"			
Correct (e.g. "bird")	65.7 (17.0)	75.7 (17.4)	75.0 (15.3)
Foil (e.g. "lord")	16.6 (13.3)	7.1 (9.8)	13.6 (13.5)
Distractors (e.g. "heap")	14.3 (13.1)	10.7 (13.8)	6.4 (8.6)
Non-response	3.4 (11.2)	6.5 (12.6)	5.0 (10.6)

@ SD in parentheses

TABLE 39

Mean Accuracy Scores (out of 16) for Rhyme Judgement Task (Experiment 9(b))

	Type 1 "word-bird"	Type 2 "rice-mice"	Type 3 "twin-dish"	Type 4 "leaf-deaf"
Poor readers:	13.25 (1.80)	14.30 (1.78)	14.55 (1.57)	12.55 (2.08)
Reading age controls:	14.35 (0.67)	14.90 (1.65)	15.10 (1.48)	13.05 (1.73)
Chronological age controls:	14.50 (1.14)	15.35 (0.87)	15.70 (0.57)	13.50 (1.98)

@ SD in parentheses

TABLE 40

Mean Percentage Correct on Recognition Memory Task (Experiment 9(b))

	Poor readers	Reading age controls	Chronological age controls
Condition A "leaf-deaf"			
Correct (e.g. "deaf")	54.2 (14.2)	55.8 (19.9)	68.8 (14.8)
Foil (e.g. "beef")	25.0 (15.3)	23.3 (13.9)	19.6 (11.9)
Distractors (e.g. "lick")	10.0 (12.5)	8.7 (9.9)	7.5 (5.9)
Non-response	10.8 (16.2)	12.2 (6.5)	4.1 (7.8)
Condition B "word-bird"			
Correct (e.g. "bird")	69.3 (15.6)	75.0 (15.3)	84.3 (11.3)
Foil (e.g. "lord")	11.4 (11.9)	13.6 (13.5)	7.9 (8.6)
Distractors (e.g. "heap")	12.8 (11.2)	6.4 (8.6)	6.4 (9.8)
Non-response	6.5 (14.2)	5.0 (10.6)	1.4 (4.4)

@ SD in parentheses

TABLE 41

Mean Percentage Recall of Phonologically Similar and Dissimilar Letters

	Mean Span	Easy Task: Similar	Easy Task: Dissimilar
Poor readers:	3.55 (0.51)	50.00 (17.20)	69.65 (18.71)
Reading age controls:	3.90 (0.30)	47.65 (13.01)	68.30 (16.39)
	Mean String Length	**Difficult Task**	
Poor readers:	6.55 (0.51)	24.70 (6.13)	27.35 (9.51)
Reading age controls:	6.90 (0.30)	27.55 (7.61)	28.90 (11.49)

@ SD in parentheses

TABLE 42

Mean Accuracy Scores (out of 16) for Rhyme Judgement Task (Experiment 10)

	Type 1 "food-rude"	Type 2 "town-down"	Type 3 "boil-safe"	Type 4 "post-lost"
Poor readers:	9.0 (2.90)	11.15 (2.78)	13.15 (2.06)	7.70 (3.23)
Reading age controls:	12.05 (2.14)	13.90 (1.83)	14.90 (1.02)	9.0 (3.23)

@ SD in parentheses

TABLE 43

Mean Percentage Correct on Recognition Memory Task (Experiment 11)

	Poor readers	Reading age controls
Condition A "post-lost"		
Correct (e.g. "lost")	70.0 (13.6)	46.2 (32.2)
Foil (e.g. "toast")	12.9 (5.7)	42.0 (27.0)
Distractors (e.g. "each")	14.6 (9.3)	11.8 (13.1)
Non-response	2.5 (5.4)	0.0 (0.0)
Condition B "food-rude"		
Correct (e.g. "rude")	37.8 (24.2)	80.0 (14.2)
Foil (e.g. "hood")	52.9 (36.7)	15.0 (10.8)
Distractors (e.g. "torn")	6.4 (8.6)	5.0 (8.4)
Non-response	2.9 (5.9)	0.0 (0)

@ SD in parentheses

C H A P T E R   10

GENERAL DISCUSSION

The experimental investigations presented in this thesis demonstrate the value of a comprehensive approach to childhood literacy disorders. By relying upon a variety of tasks aimed at interrogating both reading and spelling processes as well as underlying memory functions it has been possible to pinpoint with greater precision where the impairments may lie. The performance of the second sample of 8 year old poor readers on the reading and memory tasks in particular is clearly of theoretical interest: these children were able to use pre-lexical phonology in reading (e.g. as evidenced by the regularity effects), but appeared to have difficulties in relying upon a phonetic code in longer-term memory preferring instead a visual-orthograpic code. Such a dissociation suggests that the phonological processes implicated in word recognition cannot be equated with those related to aspects of memory coding. However, as the poor readers did exhibit evidence of phonological impairments in reading and spelling this suggests that in children the psychological processes mediating reading are not distinct from those connected with spelling. It is of interest that adults with acquired language disorders have shown clear dissociations between reading and writing strategies: Beauvois and Derouesne (1981) found that their lexical dysgraphic subject had preserved lexical reading procedures coupled with a reliance upon a phonological spelling strategy (see also Behrmann, 1987 for a discussion of a similar patient).

Group studies of reading strategies

The performances of the 2 samples of poor readers in the experiments presented in chapters 5 and 6 were interpreted in terms of a dual route model of reading. Previous research, which had also relied upon this model, had failed to arrive at consistent conclusions which meant that certain important issues remained unresolved. The phonological deficit view (Snowling, 1983) proposed that poor readers' difficulties stemmed from a deficient non-lexical reading process (i.e. grapheme-to-phoneme correspondence rules), and that by implication they read via the lexical reading mechanism. The alternative view (Ellis, 1979) held that poor readers tended to over-rely upon phonology due to a deficiency involving the lexical reading process. The phonological deficit view likens these childrens' difficulties to those of adults with acquired phonological dyslexia whose word reading is significantly superior to their non-word reading. By contrast, Ellis's proposal compares their reading difficulties to those experienced by adults with acquired surface dyslexia; surface dyslexic patients tend to rely heavily upon the phonological process as a result of an impairment connected with the lexical mechanism. Thus these patients exhibit regularity effects and, occasionally, proficient non-word reading ability.

The performance of the 2 samples of poor readers on all the reading tasks does not fit neatly into either of these two classes of acquired reading disorders. Both samples showed regularity effects, suggesting a surface dyslexic-type reading style; also, the second sample of 8 year old poor readers showed pseudohomophone effects in lexical decision and were able to read simple non-words as competently as reading age controls. Thus on these indices of phonological reading the poor readers were found to be similar to those investigated by other researchers (e.g. Beech and Harding, 1984; Treiman and Hirsh-Pasek, 1985). It is of interest that poor readers exhibiting this pattern of difficulties have been regarded as relying upon an essentially normal reading strategy which is found in younger normal children (Ellis, 1985). In terms of this view they show a retardation in their ability to acquire the skills necessary for reading via the direct visual route. The problem with this view is that it fails to spell out why such a retardation occurs or begins to lag at this critical juncture. Presumably deficiencies involving the ability to assimilate the orthographic identities of words and related visual processes are implicated, since the ability to make the transition in reading development demonstrated by Doctor and Coltheart (1980) would seem to presuppose that such functions are intact (see Holmes, 1973, 1978; and Prior and McCorrison, 1985 for a further discussion of these issues).

Other aspects of the 2 samples of poor readers' performances are not compatible with a surface dyslexic-type account of their difficulties; for example, the first sample of 8 and 11 year old poor readers were significantly less accurate than their reading age controls at pronouncing non-words (Experiment 1b), and the second sample of poor readers were also found to be consistently worse than their reading age controls at naming the complex non-words (Experiment 4(i) to 4(iii)). Thus these results are more compatible with the phonological deficit account of their reading disorder since they suggest a definite impairment in grapheme-to-phoneme processing. It is also possible that the phonological complexity of the various reading tasks differs and this may help to explain what would otherwise appear to be an inconsistent pattern of results. For example, the regularity task and the psuedohomophone task may tap into phonological skills in a less demanding way compared with the task requiring the naming of complex non-words. In terms of this interpretation the poor readers would appear to show a mild phonological reading deficit combined with some preservation of the non-lexical reading mechanism.

Analogical accounts of non-word reading (Marcel, 1980a) suggest that lexical analogies are used in naming non-lexical letter strings as opposed to abstract rule systems. In order to process non-words in terms of this approach the reader must be capable of segmenting orthographic structure and by implication recognising familiar orthographic segments in the non-word. An attempt was made to explore this possible source of the poor readers' non-word naming difficulties in experiment 7 (task 4) where they were required to carry out orthographic segmentation tasks of the same type as those used by Funnell (1983) in her study of a patient with phonological dyslexia. However, they were found to be as competent as their reading age controls on these tests which may suggest that their difficulties connected with complex non-words cannot be accounted for in terms of analogical models of non-word reading. On the other hand, the fact that the poor readers were not found to be significantly better than their reading age controls despite being older may imply that orthographic segmentation ability nevertheless determines their level of reading capacity. It would be interesting to determine whether these poor readers are as competent as reading age controls on tasks where non-lexical orthographic structures had to be detected in lexical and non-lexical printed letter strings. Such an approach may provide a more sensitive appraisal of their difficulties - in the present task they had to detect lexical segments which may be easier to identify than non-lexical segments.

If they were found to experience difficulties with orthographic segmentation when lexical factors were unavailable as props this may suggest that their perceptual development is impaired. A major view regarding normal perceptual development is that younger children perceive multi-dimensional objects in a holistic manner, that is, as integral wholes, whereas older children recognise them as consisting of conjunctions of separable features (e.g. Bruner, Olver and Greenfield, 1966; Gibson, 1969; Shepp and Swartz, 1976; Smith and Kemler, 1977; Shepp, Barrett and Kolbet, 1987). The poor readers (particularly the second sample of 8 year olds) may have a bias towards representing objects holistically, and this would help to explain why they could have problems in identifying familiar orthographic segments in the more complex non-words. Dorman (1985) in a case study of an 18 year old girl with a surface dyslexic reading style, found evidence of visual analytical problems. The subject examined by Dorman was found to have difficulty in detecting pictures concealed in an embedded context. This would seem to suggest that the ability to identify visual structures which are part of larger visual structures is tapping those processes which are connected with reading via the direct visual route. It was noted earlier that aspects of the poor readers' reading performance suggested a surface dyslexic-type reading style, and for this reason it would appear worthwhile to determine whether they would behave like Dorman's subject.

Vellutino (1979) has argued forcefully against the view that a visual-perceptual deficit is an important source of reading difficulties in childhood, and has instead proposed that the core difficulty is of a verbal nature. While his criticisms of the research in this general area may have been valid in terms of the theoretical frameworks relied upon during the 1960's-1970's (i.e. the models current at that time) they should not be regarded as ruling out a priori future attempts to identify possible perceptual correlates of reading difficulties.

Group studies of spelling and phonemic segmentation

The 2 studies presented in chapter 7 were aimed at elucidating the nature of the second sample of poor readers' spelling difficulties in terms of a dual route model of spelling (Nelson, 1980). By focusing upon the cognitive processes connected with the use of the non-lexical spelling route it was hoped that a more theoretically motivated account could be given of the common finding that their errors tend to be non-phonetic. In support of the view that phonemic segmentation skill and reliance upon the non-lexical process are dependent upon the same phonological system, was the finding that the poor readers were significantly worse than their controls at phonemic segmentation (i.e. the odd word out task), and were also found to differ qualitatively from controls in terms of their making a larger number of non-phonetic type spelling errors.

However, the poor readers did show spelling regularity effects and this implies that they possess some competence in using a rule-based procedure. These poor readers also had below average memory spans (see chapter 9, experiment 10) and this memory impairment may have aggravated their problems in utilising a phonological spelling strategy.

The present approach to the identification of an aspect of their spelling difficulties may not, however, be the most fruitful one to adopt, especially in the context of spelling difficulties in childhood. The basic problem with the current criterion of assessing their spelling errors as being either phonetic or non-phonetic is connected with the fact that many errors which would be deemed non-phonetic do not entail that the child making such an error was insensitive to the sounds of words, nor to their orthographic representation. For instance, errors such as "sgie" for "sky", and "chrap" for "trap" are non-phonetic and have been made by normal children who are in the very early stages of literacy development (e.g. Read, 1971, 1975; Treiman, 1985). As Treiman (1985) argues "a child who begins "truck" with the letters CHR is not a nonphonetic speller. The child has simply not learned which features of sounds are represented in the English spelling system." Gerber and Hall (1987), in a critical discussion of information processing approaches to spelling, recommend that we should avoid relying upon analyses of spelling errors which imply a static view of these errors (i.e. as being either "phonetic" or "non-phonetic") and instead try to elucidate such errors in terms of a developmental model of spelling. Their suggestions have much to recommend them since several authors have demonstrated that knowledge of written language acquired through reading helps to determine one's level of "phonemic awareness", and that such linguistic knowledge is also used in spelling (e.g. Ehri, 1984; Fisher, Shankweiler and Liberman, 1985; Marsh, Friedman, Welsh and Desberg, 1980). Thus it would seem worthwhile if future research in this area tried to investigate the errors made by both normal spellers and poor spellers, taking into account the inter-relationships between the phonetic and the linguistic determinants of spelling.

Case studies of 2 girls

The studies presented in chapter 8 were specifically designed to evaluate the extent to which poor readers with severe phonological deficits are representative of other poor readers. The general finding from the tasks presented in chapter 8 was that most poor readers do have relatively mild phonological deficiencies, and that a much smaller proportion have a more serious phonological deficit. This small sub-group of poor readers can, given their marked phonological deficits, be likened to patients with acquired phonological dyslexia. Since there would appear to be a continuum of phonological deficiencies affecting poor readers, rather than there being clear qualitative differences among them (as one does find in the acquired disorders of literacy) it would suggest that comparisons with patients with a particular type of acquired literacy disorder may be misleading. Such direct comparisons may encourage us to think that there are notable discontinuities among the poor reader population in terms of their literacy disorders, whereas in fact the precise nature of their cognitive deficits may be identical. Future research in this area could try to determine whether certain individual poor readers differ in theoretically significant ways from other poor readers by comparing their linguistic development over several years on both reading/spelling and memory tasks. A major weakness of the current case study approach to literacy disorders in childhood has been its tendency to provide a characterisation of the child's problems at a particular point in his or her cognitive development. Such an approach ignores the obvious and very important fact that the child is in the process of acquiring literacy and other related cognitive skills, and for this reason effectively ignores the interaction between environmental and constitutional factors. By addressing the childrens' difficulties diachronically we are also more likely to gain a better understanding of how to go about remediating their areas of weakness.

Studies of memory coding

The research described in chapter 9 was aimed at exploring the nature of the memory codes employed by poor readers in working memory and longer-term memory since the effectiveness (or appropriateness) of these codes may play a key role in determining the ease with which a child learns to read and spell. Other researchers (e.g. Jorm, 1979a, b) have suggested that some poor readers' difficulties with non-words may be connected with memory deficiencies. Johnston et al. (1987b) failed to find a signficant relationship between memory span and non-word naming skill in their samples of poor readers. However, the influence that a memory impairment may exert upon the literacy development of poor readers could involve the higher-order aspects of reading such as syntactical processing and general comprehension. For this reason it would seem premature to conclude that there is no positive association whatever between literacy development and memory development. Aspects of the results of the memory coding experiments are indeed compatible with this possibility: the poor reader samples were found to prefer an orthographic rather than a phonological memory code. Also, the second sample of 8 year old poor readers' shorter-term memories were found to be less efficient at relying upon a phonological code than their reading age controls since they were found to have significantly shorter memory spans. The ability to profit from fully intact phonological coding in short and in longer-term memory may be critical in learning to read successfully in alphabetic scripts, especially since many schools adopt a phonic approach to reading and spelling. Finally the results of these experiments replicate the pattern of Rack's (1985) findings in so far as the tests of visual recognition memory are concerned, and this suggests that the bias for a visual-orthographic code exhibited by the poor readers is a common feature of the cognitive make-up of these children.

Remedial implications

Boder (1973) recommends that the child with "dysphonetic" dyslexia (i.e. severe phonological reading/spelling deficits) receive a mixture of whole word and phonics tuition, the latter being introduced once a substantial sight vocabulary had become established. Similarly, Henry (1975) suggests a whole word approach for children whose deficits are of an auditory-perceptual nature (see Fernald, 1943 for a classic account of the whole word approach; and for a description of the alternative phonic-based methodology see Gillingham and Stillman, 1956). Using a combination of both these approaches multi-sensory remediation techniques aim to strengthen the use of all the available learning channels including that of touch (see e.g. Thomas, 1977; Cotterell, 1976; Hickey, 1977 for accounts of this approach, and Chall, 1967 for a description of methods of teaching reading; and an excellent chapter length survey of research dealing with the efficacy of the various types of remediation can be found in Tansley and Panckhurst, 1981). In recent years several researchers concerned with the remediation of reading and spelling deficits in adult patients (e.g. Behrmann, 1987; De Partz, 1986; Byng and Coltheart, 1986) have successfully applied remediation programmes which are derived from a cognitive model of the literacy impairment, and have argued that such an approach permits a more rigorous appraisal of the effects of a particular treatment. It would be interesting to determine whether a similar remedial approach would work with children. A point in favour of such a more theoretically motivated approach would be that remediation would be founded upon exactly the same kind of cognitive analysis used in the initial characterisation of the impairment. Given that the poor readers examined in the present thesis exhibited phonological deficiencies to varying extents a combination of a whole word and phonics methodologies would appear to provide the basis for the most appropriate remedial programme for their reading difficulties.

BIBLIOGRAPHY

1. Backman, J., Bruck, M., Hebert, M. Seidenberg, M.S. (1984) Acquisition and use of spelling-sound correspondences in reading. Journal of Experimental Child Psychology, 36, 114-133.

2. Backman, J., Manen, M. and Ferguson, H.B. (1984) Reading level design: Conceptual and Methodological Issues in Reading Research. Psychological Bulletin, 96, 560.568.

3. Baddeley, A.D. (1979) Working memory and reading. In P.A. Kolers, M.E. Wrolstad and M. Bourne (Eds.) The Proceedings of the Conference on the Processing ov Visible Language, Eindhoven.

4. Baddeley, A.D. (1981) The concept of working memory: a view of its current state and probable future development. Cognition, 10, 17-23.

5. Baddeley, A.D. (1982) Reading and working memory. Bulletin of the British Psychological Society, 35, 414-417.

6. Baddeley, A.D. (1983) Working memory. Philosophical Transactions of the Royal Society of London, B302, 311-324.

7. Baddeley, A.D., Ellis, N.C., Miles, T.R. and Lewis, V.J. (1982) Developmental and acquired dyslexia: a comparison. Cognition, 11, 185-199.

8. Baddeley, A.D. and Hitch, G. (1974) Working memory. In G.H. Bower (Ed.) Recent Advances in Learning and Motivation, VIII, 47-89.

9. Baddeley, A.D. and Liberman, K. (1980) Spatial working memory. In R.S. Nickerson (Ed.) Attention and Performance, VIII, Hillsdale, N.J.: Erlbaum.

10. Baron, J. (1977) What we might know about orthographic rules. In S. Dornic (Ed.) Attention and Performance, VI, Hillsdale, N.J.: Erlbaum.

11. Baron, J. (1979) Orthographic and word-specific mechanisms in children's reading of words. Child Development, 50, 60-72.

12. Baron, J. and Strawson, C. (1976) Use of orthographic and word specific knowledge in reading words aloud. Journal of Experimental Psychology: Human Perception and Performance, 2, 386-393.

13. Barron, R.W. (1978) Reading skill and phonological coding in lexical access. In M. Gruneberg, R. Sykes and P. Morris (Eds.) Practical Aspects of Memory, London: Academic Press.

14. Barron, R.W. (1980) Visual and phonological strategies in reading and spelling. U. Frith (Ed.) Cognitive Processes in Spelling, London: Academic Press.

15. Barry, C. (1981) Hemispheric asymmetry in lexical access and phonological encoding. Neuropsychologia, 19, 3, 473-478.

16. Bauer, D.W. and Stanovich, K.E. (1980) Lexical access and the spelling-to-sound regularity effect. Memory and Cognition, 4, 674-690.

17. Bauer, R. (1977) Memory processes in children with learning disabilities. Journal of Experimental Child Psychology, 24, 415-430.

18. Baxter, D.M. and Warrington, E.K. (1987) Transcoding Sound to Spelling: Single or Multiple Sound Unit Correspondences? Cortex, 23, 11-28.

19. Beauvois, M-F. and Derouesne, J. (1979) Phonological alexia: three dissociations. Journal of Neurology, Neurosurgery and Psychiatry, 42, 1115-1124

20. Beauvois, M-F. and Derouesne, J. (1981) Lexical or Orthographic Agraphia, 104, 21-49.

21. Beech, J.R. and Harding, L.M. (1984) Phonetic processing and the poor reader from a developmental lag viewpoint. Reading Research Quarterly, 19, 357-366.

22. Behrmann, M. (1987) The rites of righting writing: homophone remediation in acquired dysgraphia. Cognitive Neuropsychology, 4, 365-384.

23. Bender, L.A. (1957) Specific reading disability as a maturational lag. Bulletin of the Orton Society, 7, 9-18.

24. Benton, A.L. (1965) Sentence Memory Text, Iowa City: A.L. Benton.

25. Bissex, G.L. (1980) GNYS at work: a child learns to write and read. Cambridge, M.A.: Harvard University Press.

26. Boder, E. (1970) Developmental dyslexia: a new diagnostic approach based on the identification of three sybtypes. Journal of School Health, 40, 289-290.

27. Boder, E. (1973) Developmental dyslexia: a diagnostic approach based on three atypical reading-spelling patterns. Developmental Medicine and Child Neurology, 15, 663-687.

28. Bradley, L. and Bryant, P.E. (1978) Difficulties in auditory organisation as a possible cause of reading backwardness. Nature, 271, 746-747.

29. Bradley, L. and Bryant, P.E. (1979) Independence of reading and spelling in backward and normal readers. Developmental Medicine and Child Neurology, 21, 504-514.

30. Bradley, L. and Bryant, P. (1981) Visual memory and phonological skills in reading and spelling backwardness. Psychological Research, 43, 193-199.

31. Bradley, L. and Bryant, P.E. (1983) Categorising sounds and learning to read - a causal connection. Nature, 301, 419-421.

32. Bradley, L. and Bryant, P.E. (1985) Rhyme and reason in reading and spelling. Ann Arbor: University of Michigan Press.

33. Bruce, D.J. (1964) The analysis of word sounds by young children. British Journal of Educational Psychology, 34, 158-170.

34. Bruner, J.S., Olver, R.R. and Greenfield, P.M. (1966) Studies in Cognitive Growth, New York: Wiley.

35. Bryant, P.E. and Impey, L. (1986) The similarities between normal readers and developmental and acquired dyslexics. Cognition, 24, 121-137.

36. Bub, D. and Kertesz, A. (1982) Deep agraphia. Brain and Language, 17, 146-165.

37. Byng, S. and Coltheart, M. (1986) Aphasia therapy research: methodological requirements and illustrative results. In E. Hjelmquist and L.B. Nilsson (Eds.) Communication and Handicap, Amsterdam: North Holland.

38. Byrne, B. and Shea, P. (1979) Semantic and phonetic memory codes in beginning readers. Memory and Cognition, 7, 68-76.

39. Calfee, R.C., Lindamood, P. and Lindamood, C. (1973) Acoustic-phonetic skills and reading - kindergarten to twelfth grade. Journal of Educational Psychology, 64, 293-298.

40. Campbell, R. (1985) When children write nonwords to dictation. Journal of Experimental Child Psychology, 40, 133-151.

41. Caramazza, A., Miceli, G. and Villa, G. (1986) The role of the (output) phonological buffer in reading, writing and repetition. Cognitive Neuropsychology, 3, 37-76.

42. Carroll, J., Davies, P. and Richman, B. (1971) The American Heritage Word Frequency Book, New York: American Heritage Publishing Co.

43. Case, R., Kurland, M.D., Goldberg, J. (1982) Operational efficiency and the growth of short-term memory span. Journal of Experimental Child Psychology, 33, 386-404.

44. Chall, J. (1967) Learning to Read: the Great Debate, New York: McGraw-Hill.

45. Clifton-Everest, I.M. (1976) Dyslexia: Is there a disorder of visual perception? Neuropsychologia, 14, 491-494.

46. Coltheart, M. (1978) Lexical access in simple reading tasks. In G. Underwood (Ed.) Strategies of Information Processing, London: Academic Press.

47. Coltheart, M. (1980a) Deep dyslexia: a review of the syndrome. In M. Coltheart, K. Patterson and J.C. Marshall (Eds.) Deep Dyslexia, London: Routledge and Kegan Paul.

48. Coltheart, M. (1980b) The semantic error: types and theories. In M. Coltheart, K. Patterson and J.C. Marshall (Eds.) Deep Dyslexia, London: Routledge and Kegan Paul.

49. Coltheart, M. (1981a) Disorders of reading and their implications for models of normal reading. Visible Language, 15, 245-286.

50. Coltheart, M. (1981b) Analysing acquired disorders of reading. Unpublished manuscript, Birkbeck College.

51. Coltheart, M. (1982) Surface dyslexia and its implications for models of normal reading. In D.E. Broadbent and L. Weiskrantz (Eds.) The Neuropsychology of Cognitive Function. London: The Royal Society.

52. Coltheart, M. (1983) Phonological awareness: a preschool precurser of success in reading: Nature, 301, 370.

53. Coltheart, M. (1985) Cognitive neuropsychology and the study of reading. In M.I. Posner and O.S.M. Marin (Eds.) Attention and Performance, 11, London: Erlbaum.

54. Coltheart, M., Besner, D., Jonasson, J.T. and Davelaar, E. (1979) Phonological recoding in the lexical decision task. Quarterly Journal of Experimental Psychology, 31, 489-508.

55. Coltheart, M., Davelaar, E., Jonasson, J.T. and Besner, D. (1977) Access to the internal lexicon. In S. Dornic (Ed.) Attention and Performance, VI, Hillsdale, N.J.: Erlbaum.

56. Coltheart, M., Masterson, J., Byng, S., Prior, M. and Riddoch, J. (1983) Surface dyslexia. Quarterly Journal of Experimental Psychology, 35A, 469-496.

57. Coltheart, M., Patterson, K.E. and Marshall, J.C. (Eds.) (1980) Deep Dyslexia. London: Routledge and Kegan Paul.

58. Conrad, R. (1964) Acoustic confusions in immediate memory. British Journal of Psychology, 55, 75-84.

59. Conrad, R. (1971) The chronology of the development of covert speech in children. Developmental Psychology, 5, 398-405.

60. Content, A., Kolinsky, R., Morais, J. and Bertelson, P. (1986) Phonetic segmentation in prereaders: effect of corrective information. Journal of Experimental Child Psychology, 42, 49-72.

61. Cotterell, G.C. (1976) Nigel: a severe auditory dyslexic. Special Education: Forward Trends, 3, 4, 19-21.

62. Critchley, M. (1968) Topics worthy of research. In A.H. Keeney and V.T. Keeney (Eds.) Dyslexia, Diagnosis and Treatment of Reading Disorders, St. Louis, Mosby.

63. Cromer, R.F. (1980) Spontaneous spelling by language disorderd children. U. Frith (Ed.) Cognitive Processes in Spelling, London: Academic Press.

64. Crowder, R.G. (1982) The Psychology of Reading, New York: Cambridge University Press.

65. Davelaar, E., Coltheart, M., Besner, D. and Jonasson, J.T. (1978) Phonological recoding and lexical access. Memory and Cognition, 1, 106-120.

66. De Hirsch, K. (1968) Specific dyslexia or strephosymbolia. In G. Natchez (Ed.) Children with Reading Problems: Classic and Contemporary Issues in Reading Disability, New York: Basic Books.

67. De Partz, M.P. (1986) Re-education of a deep dyslexic patient: rationale of the method and results. Cognitive Neuropsychology, 3, 149-177.

68. Denckla, M.B. and Rudel, R.G. (1974) Rapid "automatised" naming of pictured objects, colors, letters and numbers by normal children. Cortex, 10, 186-202.

69. Denckla, M.B. and Rudel, R.G. (1976) Naming of object-drawings by dyslexic and other learning disabled children. Brain and Language, 3, 1-15.

70. Derouesne, J. and Beauvois, M.F. (1979) Phonological processes in reading: data from alexia. Journal of Neurology, Neurosurgery and Psychiatry, 42, 1125-1132.

71. Di Benedetto, B., Richardson, E. and Kochnower, J. (1983) Vowel generalisation in normal and learning disabled readers. Journal of Educational Psychology, 75, 576-582.

72. Di Lollo, V., Hanson, D. and McIntyre, J.S. (1983) Initial stages of visual information processing in dyslexia. Journal of Experimental Psychology: Human Perception and Performance, 9, 923-935.

73. Doctor, E.A. and Coltheart, M. (1980) Childrens use of phonological encoding when reading for meaning. Memory and Cognition, 8, 195-209.

74. Doctor, E.A., Coltheart, M. and Jonasson, J. (1982) Aspects of reading and learning to read (unpublished manuscript).

75. Donnenwerth-Nolan, S., Tanenhaus, M.K. and Seidenberg, M.S. (1981) Multiple code activation in word recognition: evidence from rhyme monitoring. Journal of Experimental Psychology: Human Learning and Memory, 7, 170-180.

76. Dorman, C. (1985) Classification of reading disability in a case of congenital brain damage. Neuropsychologia, 23, 393-402.

77. Dunn, L.M. (1965) The Peabody Picture Vocabulary Test, Circle Press: American Guidance Service.

78. Edfelt, A.W. (1960) Silent Speech and Silent reading, Chicago: University of Chicago Press.

79. Ehri, L.C. (1984) How orthography alters spoken language competencies in children learning to read and spell. In J. Downing and R. Valtin (Eds.) Language Awareness and Learning to Read, 119-147, New York: Springer-Verlag.

80. Elliott, C.D., Murray, D.J. and Pearson, L.S. (1977) The British Ability Scales, Windsor: NFER Nelson.

81. Ellis, A.W. (1979) Developmental and acquired dyslexia: some observations on Jorm (1979). Cognition, 7, 421-433.

82. Ellis, A.W. (1982) Spelling and writing (and reading and speaking). In A.W. Ellis (Ed.) Normality and Pathology in Cognitive Functions, London: Academic Press.

83. Ellis, A.W. (1984) Reading, Writing and Dyslexia: a Cognitive Analysis, London: Erlbaum.

84. Ellis, A.W. (1985) The cognitive neuropsychology of developmental (and acquired) dyslexia: a critical survey. Cognitive Neuropsychology, 2, 169-205.

85. Ellis, N. and Large, B. (1987) The development of reading: as you seek so shall you find. British Journal of Psychology, 78, 1-28.

86. Fernald, G.M. (1943) Remedial Techniques in Basic School Subjects. New York: McGraw-Hill.

87. Finucci, J.M., Isaacs, S.D., Whitehouse, C.C. and Childs, B. (1983) Classification of spelling errors and their relationship to reading ability, sex, grade placement and intelligence. Brain and Language, 20, 340-355.

88. Firth, I. (1972) Components of Reading Disability, unpublished doctoral dissertation, University of New South Wales.

89. Fischer, F.W., Shankweiler, D. and Liberman, I.Y. (1985) Spelling Proficiency and Sensitivity to Word Structure, Journal of Memory and Language, 24, 423-441.

90. Forster, K.I. (1981) Priming and the effects of sentence and lexical contexts on naming time: evidence for autonomous lexical processing. Quarterly Journal of Experimental Psychology, 33A, 465-495.

91. Fox, B. and Routh, D.K. (1975) Analysing spoken language into words, syllables and phonemes: a developmental study. Journal of Psycholinguistic Research, 4, 331-342.

92. Frith, U. (1980) Unexpected spelling problems. In U. Frith (Ed.) Cognitive Processes in Spelling, London: Academic Press.

93. Frith, U. (1985) Beneath the surface of developmental dyslexia. In M. Coltheart, K.E. Patterson and J.C. Marshall (Eds.) Surface Dyslexia, London: Routledge and Kegan Paul.

94. Frith, U. and Snowling, M.J. (1983) Reading for meaning and reading for sound in autistic and dyslexic children. British Journal of Developmental Psychology, 1, 329-342.

95. Funnell, E. (1983) Phonological processes in reading: new evidence from acquired dyslexia. British Journal of Psychology, 74, 159-180.

96. Gentry, R.J. (1981) Learning to spell developmentally. The Reading Teacher, 34, 378-381.

97. Gerber, M.M. and Hall, R.J. (1987) Information processing approaches to studying spelling deficiencies. Journal of Learning Disabilities, 20, 34-42.

98. Gibson, E.J. (1969) Principles of Perceptual Learning and Development, New York: Academic Press.

99. Gibson, E.J. and Levin, H. (1975) The Psychology of Reading, Cambridge, M.A.: MIT Press.

100. Gillingham, A. and Stillman, B. (1956) Remedial Training for Children with Specific Language Disability in Reading, Spelling and Penmanship, Cambridge, Mass.: Educators Publishing Service.

101. Glushko, R.J. (1979) The organisation and activation of orthographic knowledge in reading words aloud. Journal of Experimental Psychology: Human Perception and Performance, 5, 674-691.

102. Glushko, R.J. (1981) Principles for pronouncing print: the psychology of phonography. In A.M. Lesgold and C.A. Perfetti (Eds.) Interactive Processes in Reading, Hillsdale, N.J.: Laurence Earlbaum.

103. Godfrey, J.J., Syrdal-Lasky, A.K., Millay, K.K. and Knox, C.M. (1981) Performance of dyslexic children on speech perception tests. Journal of Experimental Child Psychology, 32, 401-424.

104. Golinkoff, R.M. (1978) Phonemic awareness skills and reading achievement. In F. Murray and J. Pikulski (Eds.) The Acquisition of Reading. Baltimore, M.D.: University Park Press.

105. Goodman-Schulman, R. and Caramazza, A. (1987) Patterns of dysgraphia and the nonlexical spelling process. Cortex, 23, 143-148.

106. Goswami, U. (1986) Children's use of analogy in learning to read: a developmental study. Journal of Experimental Child Psychology, 42, 73-83.

107. Gough, P.B. and Cosky, M.J. (1977) One second of reading again. In N.J. Castellan, D.B. Pisoni and G.R. Potts (Eds.) Cognitive Theory, 2, Hillsdale, N.J.: Elrbaum.

108. Goyen, J.D. and Martin, M. (1977) The relation of spelling errors to cognitive variables and word type. British Journal of Educational Psychology, 47, 268-273.

109. Guthrie, J. and Seifert, M. (1977) Letter-sound complexity in learning to identify words. Journal of Educational Psychology, 69, 686-696.

110. Hall, J.W., Wilson, K.P., Humphreys, M.S., Tinzmann, M.B. and Bowyer, P.M. (1983) Phonemic-similarity effects in good vs. poor readers. Memory and Cognition, 11, 520-527.

111. Hanna, R.R., Hanna, J.S., Hodges, R.E. and Rudorf, E.H. (1966) Phoneme-Grapheme Correspondeces as Cues to Spelling Improvement, U.S. Department of Health, Education and Welfare, Office of Education, Wahsington, D.C.: U.S. Government Printing Office.

112. Hatfield, F.M. (1982) Aspects of acquired dysgraphia and implications for re-education. In C. Code and D.J. Muller (Eds.) Aphasia Therapy, London: Edward Arnold.

113. Hatfield, F.M. and Patterson, K.E. (1983) Phonological spelling. Quarterly Journal of Experimental Psychology, 35A, 451-468.

114. Helfgott, J.A. (1976) Phonemic segmentation and blending skills in kindergarden children. Implications for beginning reading acquisition. Contemporary Educational Psychology, 1, 157-169.

115. Henderson, L. (1981) Information processing approaches to acquired dyslexia. Quarterly Journal of Experimental Psychology, 33A, 507-522.

116. Henderson, L. (1982) Orthography and Word Recognition in Reading, London: Academic Press.

117. Henderson, L. (1985) Issues in the modelling of pronunciation assembly in normal reading. In K.E. Patterson, J.C. Marshall and M. Coltheart (Eds.) Surface Dyslexia: Cogntive and Neuropsychological Studies of Phonological Reading, London: Lawrence Erlbaum Associates Limited.

118. Henry, A. (1975) Specific difficulties in reading. Remedial Education, 10, 2, 81-85.

119. Herman, K. (1959) Reading Disability, Copenhagen: Munksgaard.

120. Hickey, K. (1977) Dyslexia: A Language Training Course for Teachers and Learners, 3, Montague Road, London, SW19.

121. Higgins, C. and Werman, H. (1968) Higgins-Wertman Test of Visual Closure, Albany, N.Y.: C. Higgins and H. Wertman.

122. Hogaboam, T. and Perfetti, C.A. (1978) Reading skill and the role of verbal experience in decoding. Journal of Educational Psychology, 70, 717-729.

123. Holmes, D.L. and Peper, R.J. (1977) An evaluation of the use of spelling error analysis in the diagnosis of reading disabilities. Child Development, 48, 1708-1711.

124. Holmes, J.M. (1973) Dyslexia: a neurolinguistic study of traumatic and developmental disorders of reading. Ph.D. thesis, University of Edinburgh.

125. Holmes, J.M. (1978) "Regression" and reading breakdown. In A. Caramazza, and E. Zurif (Eds.) Language Acquisition and Language Breakdown: Parallels and Divergencies, Baltiome: John Hopkins University Press.

126. Horn, T.D. (1969) Spelling. In R.L. Ebels (Ed.) Encylopedia of Educational Research, 4th ed., New York: MacMillan.

127. Hulme, C., Thomson, N., Muir, C. and Lawrence, A. (1984) Speech rate and the development of short-term memory span. Journal of Experimental Child Psychology, 38.

128. Humphreys, G.W. and Evett, L. (1985) Are there independent lexical and non-lexical routes in word processing? An evaluation of the dual route theory of reading. Behavioural and Brain Sciences, 8, 689-739.

129. Hung, D.L. and Tzeng, O.J.L. (1981) Orthographic variations and visual information processing. Psychological Bulletin, 90, 377-414.

130. Ingram, T.T.S. (1959) Specific developmental disorders of speech in childhood. Brain, 82, 450-467.

131. Ingram, T.T.S. (1962) Delayed development of speech with special reference to dyslexia. Proceedings of the Royal Society of Medicine, 56, 199-203.

132. Ingram, T.T.S. (1970) The nature of dyslexia. In F.A. Young and D.B. Lindsley (Eds.) Early Experience and Visual Information Processing in Reading Disorders. Washington, D.C.: National Academic of Sciences.

133. Ingram, T.T.S., Mason, A.W. and Blackburn, I. (1970) A retrospective study of 82 children with reading disability. Developmental Medicine and Child Neurology, 17, 150-163.

134. Jakimik, J., Cole, R.A. and Rudnicky, A. (1985) Sound and spelling in spoken word recognition. Journal of Memory and Language, 24, 165-178.

135. Johnston, R.S. (1982) Phonological coding in dyslexic readers. British Journal of Psychology, 73, 455-460.

136. Johnston, R.S. (1983) Developmental deep dyslexia? Cortex, 19, 133-139.

137. Johnston, R.S. and McDermott, E.A. (1986) Suppression effects in rhyme judgement tasks. Quarterly Journal of Experimental Psychology, 38A, 111-124.

138. Johnston, R.S., Rugg, M.D. and Scott, T. (1987a) The influence of phonology on good and poor readers when reading for meaning. Journal of Memory and Language, 26, 57-68.

139. Johnston, R.S., Rugg, M.D. and Scott, T. (1987b) Phonological similarity effects, memory span and developmental reading disorders: the nature of the relationship. British Journal of Psychology, 78, 205-211.

140. Jorm, A.F. (1977) The effect of imagery on reading performance as a function of reading ability. Journal of Educational Psychology, 69, 46-54.

141. Jorm, A.F. (1979a) The nature of the reading deficit in developmental dyslexia: a reply to Ellis. Cognition, 7, 421-433.

142. Jorm, A.F. (1979b) The cognitive and neurological bases of developmental dyslexia: a theoretical framework and review. Cognition, 7, 19-33.

143. Jorm, A.F. (1981) Children with reading and spelling retardation: functioning of whole-word and correspondence-rule mechanisms. Journal of Child Psychology and Psychiatry, 22, 171-178.

144. Jorm, A.F. (1983) Specific Reading Retardation and Working Memory: A Review, British Journal of Psychology, 74, 311-342.

145. Jorm, A.F. and Share, D.L. (1983) Phonological recoding and reading acquisition. Applied Psycholinguistics, 4, 103-147.

146. Kass, C.E. (1964) Auditory closure test. In J.J. Olson and J.L. Olson (Eds.) Validity Studies on the Illinois Test of Psycholinguistic Abilities, Madison, W.I.: Photo Press.

147. Kay, J. and Marcel, A.J. (1981) One process, not two, in reading aloud: lexical analogies do the work of non-lexical rules. Quarterly Journal of Experimental Psychology, 33A, 397-414.

148. Kinsbourne, M. and Warrington, E.K. (1963) Developmental factors in reading and writing backwardness. British Journal of Psychology, 54, 145-156.

149. Kinsbourne, M. and Warrington, K.E. (1964) Disorders of spelling. Journal of Neurology, Neurosurgery and Psychiatry, 27, 296-299.

150. Kirk, S., McCarthy, J. and Kirk, W. (1968) The Illinois Test of Psycholinguistic Abilities, Revised Edition, Urbana: University of Illinois Press.

151. Kochnower, J., Richardson, E. and Di Benedetto, B. (1983) A comparison of the phonic decoding ability of normal and learning disabled children. Journal of Learning Disabilities, 16, 348-351.

152. Kremin, H. (1982) Neurolinguistic aspects of reading disorders due to lesions of the left hemisphere. Paper presented at NATO Advanced Study Institute: Dyslexia: A Global Issue, Maratea, Italy.

153. Lewkowicz, N.K. (1980) Phonemic awareness training: what to teach and how to teach it. Journal of Educational Psychology, 72, 686-700.

154. Liberman, I.Y. (1973) Segmentation of the spoken word and reading acquisition. Bulletin of the Orton Society, 25, 65-77.

155. Liberman, I.Y., Rubin, H., Duques, S.L. and Carlisle, J. (in press) Linguistic skills and spelling proficiency in kindergardeners and adult poor spellers. In J. Kavanaugh, D. Gray and D. Pearl (Eds.) Dyslexia: Biology and Behaviour, Parkton, M.D.: Yolk Press.

156. Lindamood, C.H. and Lindamood, P.C. (1971) Lindamood Auditory Conceptualisation Test, Boston: Teaching Resources Corporation.

157. Lovegrove, Martin, F. and Slaghuis, W. (1986) A theoretical and experimental case for a visual deficit in reading disability. Cognitive Neuropsychology, 3, 225-267.

158. Luria, A.R. (1973) The Working Brain, New York, Basic Books.

159. McCarthy, R. and Warrington, E.K. (1986) Phonological reading: phenomena and paradoxes. Cortex,22, 359-380.

160. McClelland, J.L. and Rumelhart, D.E. (1981) An interactive activation model of context effects in letter perception. Part I: an account of basic findings. Psychological Review, 88, 375-407.

161. McClelland, J.L. and Rumelhart, D.E. (1982) An interactive activation model of context effects in letter perception. Part 2: the contextual enhancement effect and some tests and extensions of the model. Psychological Review, 89, 60-94.

162. McCusker, L.X., Hillinger, M.L. and Bias, R.G. (1981) Phonological recoding and reading. Psychological Bulletin, 89, 217-245.

163. McQuade, D.V. (1981) Variable reliance on phonological information in visual word recognition. Language and Speech, 24, 99-109.

164. Makita, K. (1968) The rarity of reading disability in Japanese children. American Journal of Orthopsychiatry, 38, 599-614.

165. Mann, V.A. (1984) Longitudinal prediction and prevention of early reading difficulty. Annals of Dyslexia, 34, 117-136.

166. Mann, V.A., Liberman, I.Y. and Shankweiler, D. (1980) Children's memory for sentences and word strings in relation to reading ability. MEMORY AND COGNITION 4, 329-335.

167. Marcel, T. (1980a) Surface dyslexia and beginning reading: a revised hypothesis of the pronunciation of print and its impairments. In M. Coltheart, K. Patterson and J.C. Marshall (Eds.) Deep Dyslexia, London: RKP.

168. Marcel, T. (1980b) Phonological awareness and phonological representation: investigation of a specific spelling problem. In U. Frith (Ed.) Cognitive Processes in Spelling, London: Academic Press.

169. Margolin, D.I. (1984) The neuropsychology of writing and spelling. Semantic, phonological, motor and perceptual processes. Quarterly Journal of Experimental Psychology, 36A, 459-489.

170. Mark, L.S., Shankweiler, D., Liberman, I.Y. and Fowler, C.A. (1977) Phonetic recoding and reading difficulty in beginning readers. Memory and Cognition, 5, 623-629.

171. Marsh, G., Desberg, P. and Cooper, J. (1977) Developmental changes in strategies of reading. Journal of Reading Behaviour, 9, 391-394.

172. Marsh, G., Friedman, M., Welch, V. and Desberg, P. (1980) The development of strategies in spelling. In U. Frith (Ed.) Cognitive Processes in Spelling, London: Academic Press.

173. Marshall, J.C. (1976) Neuropsychological aspects of orthographic representation. In R.J. Wales and E. Walker (Eds.) New Approaches to Language Mechanisms. A Collection of Psycholinguistic Studies, Amsterdam: North-Holland.

174. Marshall, J.C. (1982) Biological constraints on orthographic representation. Philosophical Transactions of the Royal Society, London, B298, 165-172.

175. Marshall, J.C. (1984) Toward a rational taxonomy of the developmental dyslexias. In R.N. Malatesha and H.A. Whitaker (Eds.) Dyslexia: A Global Issues, The Hague: Martinus Nijhoff.

176. Marhsall, J.C. and Newcombe, F. (1973) Patterns of paralexia: a psycholinguistic approach. Journal of Psycholinguistic Research, 2, 175-199.

177. Martin, R.C. (1982) The pseudohomophone effect: the role of visual similarity in non-word decisions. Quarterly Journal of Experimental Psychology, 34A, 395-409.

178. Mason, A.W. (1967) Specific (develomental) dyslexia. Developmental Medicine and Child Neurology, 9, 183-190.

179. Mattingly, I.G. (1972) Reading: the linguistic process and linguistic awareness. In J.F. Kavanagh and I.G. Mattingly (Eds.) Language by Ear and by Eye, Cambridge, Mass.: MIT Press.

180. Mattingly, I.G. (1980) Reading, linguistic awareness, and language acquisition. Haskins Laboratories Status Report on Speech Research, SR-61, 135-150.

181. Mattis, S., French, J.H. and Rapin, I. (1975) Dyslexia in children and adults: three independent neurological syndromes. Developmental Medicine and Child Neurology, 17, 150-163.

182. Maxwell, A.E. (1959) A factor analysis of the Wechsler Intelligence Scale for Children. British Journal of Educational Psychology, 29, 237-241.

183. Mayzner, M.S. and Tresselt, M.E. (1965) Tables of single-letter and digram frequency counts for various word length and letter position combinations. Psychonomic Science Monograph Supplements, 1, 13-32.

184. Meyer, D. and Schvaneveldt, R.W. (1971) Facilitation in recognising pairs of words: evidence for a dependence between retrieval operations. Journal of Experimental Psychology, 102, 768-772.

185. Meyer, D. and Schvaneveldt (1974) Facilitation in recognising pairs of words: evidence for a dependence between retrieval operations. Journal of Experimental Psychology, 102, 768-772.

186. Meyer, D.E., Schvaneveldt, R.W. and Ruddy, M.G. (1974) Functions of graphemic and phonemic codes in visual word-recognition. Memory and Cognition, 2, 309-321.

187. Miles, T.R. (1974) The Dyslexic Child, Hove, Sussex: Priory Press.

188. Miles, T.R. (1983) Dyslexia. The Pattern of Difficulties, London: Granada.

189. Mitterer, J.O. (1982) There are at least two kinds of poor readers: whole word poor readers and recoding poor readers. Canadian Journal of Psychology, 36, 445-461.

190. Money, J. (1966) On learning and not learning to read. In J. Money (Ed.) The Disabled Reader: Education of the Dyslexic Child, Baltimore: John Hopkins Press.

191. Montgomery, D. (1981) Do dyslexics have difficulty accessing articulatory information? Psychological Research, 43, 235-243.

192. Morais, J., Cary, L., Algeria, J. and Bertelson, P. (1979) Does awareness of speech as a sequence of phones arise spontanteously? Cognition, 7, 323-331.

193. Morton, J. (1981) Will cognition survive? Cognition, 10, 227-234.

194. Morton, J. and Patterson, K. (1980) A new attempt at an interpretation, or, an attempt at a new interpretation. In M. Coltheart, K. Patterson and J.C. Marshall (Eds.) Deep Dyslexia, London: RKP.

195. Naidoo, S. (1972) Specific Dyslexia, Londn: Pitman.

196. Nelson, H.E. (1980) Analysis of spelling errors in normal and dyslexic children. In U. Frith (Ed.) Cognitive Processes in Spelling, pp. 475-493.

197. Nelson, H.E. and Warrington, E.K. (1974) Developmental spelling retardation and its relation to other cognitive abilities. British Journal of Psychology, 65, 265-274.

198. Newcombe, F. and Marshall, J.C. (1980) Transcoding and lexical stabilisation in deep dyslexia. In M. Coltheart, K.E. Patterson and J.C. Marshall (Eds.) Deep Dyslexia, London: Routledge and Kegan Paul.

199. Nolan, K.A. and Caramazza, A. (1983) An analysis of writing in a case of deep dyslexia. Brain and Language, 20, 305-328.

200. Norris, D. and Brown, E. (1985) Race models and analogy theories: a dead heat? Reply to Seidenberg. Cognition, 20, 155-168.

201. Olson, R.K., Davidson, B.J., Kliegl, R. and Davies, S.E. (1984) Development of phonetic memory in disabled and normal readers. Journal of Experimental Child Psychology, 37, 187-206.

202. Olson, R.K., Kliegl, R., Davidson, B.J. and Foltz, G. (1984) Individual and developmental differences in reading disability. In T.G. Waller (Ed.) Reading Research: Advances in Theory and Practice, Vol. 4, New York: Academic Press.

203. Orton, S.T. (1937) Reading, Writing and Speech Problems in Children, London: Chapman and Hall.

204. Paap, K.R., Newsome, S.L., McDonald, J.E. and Schvaneveldt, R.W. (1982) An activation-verification model for letter and word recognition: the word superiority effect. Psychological Review, 89, 573-594.

205. Parkin, A.J. (1982) Phonological recoding in lexical decision: effects of spelling-to-sound regularity depend on how regularity is defined. Memory and Cognition, 10, 43-53.

206. Parkin, A.J. (1984) Redefining the regularity effect. Memory and Cognition, 12, 287-292.

207. Patterson, K.E. (1978) Phonemic dyslexia: errors of meaning and the meaning of errors. Quarterly Journal of Experimental Psychology, 30, 587-607.

208. Patterson, K.E. (1980) Derivational errors. In M. Coltheart, K. Patterson and J.C. Marshall (Eds.) Deep Dyslexia, London: Routledge and Kegan Paul.

209. Patterson, K.E. (1981) Neuropsychological approaches to the study of reading. British Journal of Psychology, 72, 151-174,

210. Patterson, K.E. (1982) The relation between reading and phonological coding: further neuropsychological observations. In A.W. Ellis (Ed.) Normality and Pathology in Cognitive Functions, London: Academic Press.

211. Patterson, K.E. and Marcel, A.J. (1977) Aphasia, dyslexia and the phonological coding of written words. Quarterly Journa of Experimental Psychology, 29, 307-318.

212. Patterson, K.E. and Morton, J. (1985) From Orthography to Phonology: an Attempt at an Old Interpretation. Surface Dyslexia: Cognitive and Neuropsychological Studies of Phonological reading, London: Lawrence Erlbaum Associates Limited.

213. Pavlidis, G. Th. (1981) Sequencing, eye movements and the early objective diagnosis of dyslexia. In G.Th. Pavlidis and T.R. Miles (Eds.) Dyslexia Research and its Application to Education, Chichester: John Wiley.

214. Perfetti, C.A. and Hogaboam, T. (1975) Relationship between single word decoding and reading comprehension skill. Journal of Educational Psychology, 67, 461-469.

215. Perin, D. (1983) Phonemic segmentation and spelling. British Journal of Psychology, 74, 129-144.

216. Pring, L. (1981) Phonological codes and functional spelling units: reality and implications. Perception and Psychophysics, 30, 573-578.

217. Pringle, M.K., Butler, N.R. and Davies, R. (1966) 11,000 Seven-Year Olds, London: Longmans.

218. Prior, M. and McCorriston, M. (1985) Surface dyslexia: a regression effect? Brain and Language, 25, 52-71.

219. Rack, J.P. (1985) Orthographic and phonetic coding in developmental dyslexia. British Journal of Psychology, 76, 325-340.

220. Read, C. (1971) Pre-school children's knowledge of English phonology. Harvard Educational Review, 41, 1-34.

221. Read, C. (1975) Lessons to be learned from the preschool orthographer. In E.L. Henneberg (Ed.) Foundations of Language Development: A Multidisciplinary Approach, Vol. 11, Paris: UNESCO.

222. Reitan, R.M. (1955) Certain differential effects of left and right cerebral lesions in human adults. Journal of Comparative and Physiological Psychology, 48, 474-477.

223. Reitan, R.M. (1966) A research program on the psychological effects of brain lesions in human beings. In N.R. Ellis (Ed.) International Review of Research in Mental Retardation, New York: Academic Press, Vol. 1, 153-218.

224. Richardson, J.T.E (1975a) The effect of word imageability in acquired dyslexia. Neuropsychologia, 13, 281-8.

225. Richardson, J.T.E. (1975b) Further evidence on the effect of the word imageability in dyslexia. Quarterly Journal of Experimental Psychology, 27, 445-9.

226. Roeltgen, D.P. and Heilman, K.M. (1984) Lexical agraphia: further support for the two-system hypothesis of linguistic agraphia. Brain, 107, 811-827.

227. Roeltgen, D.P., Serush, S. and Heilman, K.M. (1983) Phonological agraphia: writing by the lexical-semantic route. Neurology, 33, 755-65.

228. Rosner, J. and Simon, D. (1971) The auditory analysis test: an initial report. Journal of Learning Disabilities, 4, 384-392.

229. Rosson, M.B. (1983) From SOFA to LOUCH: lexical contributions to pseudoword pronunciation. Memory and Cognition, 11, 152-160.

230. Rourke, B.P. (1976) Reading retardation in children: developmental lag or deficit? In R.M. Knights and D.J. Bakker (Eds.) Neuropsychology of Learning Disorders: Theoretical Approaches, Baltimore M.D.: University Park Press, pp. 125-137.

231. Rozin, P. and Gleitman, L.R. (1977) The structure and acquisition of reading 11: the reading process and the acquisition of the alphabetic principle. In A. Reber and D. Scarborough (Eds.) Toward a Psychology of Reading: The Proceedings of the CUNY Conference, Hillsdale, N.J.: Erlbaum, pp. 55-139.

232. Rozin, P., Porkitsky, S. and Sotsky, R. (1971) American children with reading problems can easily learn to read English represented by Chinese characters. Science, 71, 1264-1267.

233. Rubenstein, H., Lewis, S.S. and Rubenstein, M.A. (1971) Evidence for phonemis recoding in visual word recognition. Journal of Verbal Learning and Verbal Behavior, 10, 645-657.

234. Rugel, R.P. (1974) W.I.S.C. subtest scores of disabled readers: a review with respect to Bannatynes recategorization. Journal of Learning Disabilities, 7, 48-55.

135. Russell, G.F.M. (1982) Writing and dyslexia - an historical analysis. Journal of Child Psychology and Psychiatry, 23, 383-400.

236. Saffran, E.M. and Marin, O.S.M. (1977) Reading without phonology: evidence from aphasia. Quarterly Journal of Experimental Psychology, 29, 515-525.

237. Salame, P. and Baddeley, A.D. (1986) Phonological factors in STM: similarity and the unattended speech effect. Bulletin of the Psychonomic Society, 24, 263-265.

238. Satz, P. and Sparrow, S.S. (1970) Specific developmental dyslexia: a theoretical formulation. In D.J. Bakker and P. Satz (Eds.) Specific Reading Disability, Rotterdam: Rotterdam University Press.

239. Schonell, F.J. (1971) Reading and Spelling Tests: Handbook of Instructions, Edinburgh: Oliver and Boyd.

240. Schwartz, M.F., Saffran, E.M. and Marin, O.S.M. (1980) Fractionating the reading process in dementia: evidence for word-specific print-to-sound associations. In M. Coltheart, K. Patterson, and J.C. Marshall (Eds.) Deep Dyslexia, London: R.K.P.

241. Seidenberg, M.S. (1985) Constraining models of word recognition. Cognition, 20, 169-190.

242. Seidenberg, M.S. and Tanenhaus, M.K. (1979) Orthographic effects on rhyme monitoring. Journal of Experimental Psychology: Human Learning and Memory, 5, 546-554.

243. Seidenberg, M.S., Waters, G., Barnes, M.A. and Tanenhaus, M.K. (1984) When does irregular spelling and pronunciation affect word recognition? Journal of Verbal Learning and Verbal Behaviour, 23, 383-404.

244. Seymour, P.H.K. (1986) Individual Cognitive Analysis of Competent and Impaired Reading. Unpublished manuscript.

245. Seymour, P.H.K. and McGregor, C.J. (1984) Developmental dyslexia: a cognitive experimental analysis of phonological, morphemic and visual impairments. Cognitive Neuropsychology, 1(1), 43-82.

246. Seymour, P.H.K. and May, G.P. (1981) Locus of Format Effects in Word Recognition. Paper presented at meeting of the Experimental Psychology Society, Oxford, 1981.

247. Seymour, P.H.K. and Porpodas, C.D. (1980) Lexical and non-lexical processing of spelling in dyslexia. In U. Frith (Ed.) Cognitive Processes in Spelling, London: Academic Press.

248. Shallice, T. (1981) Phonological agraphia and the lexical route in writing. Brain, 104, 413-429.

249. Shallice, T. and Warrington, E.K. (1975) Word recognition in a phonemic dyslexic patient. Quarterly Journal of Experimental Psychology, 27, 187-99.

250. Shallice, T. and Warrington, E.K. (1980) Single and multiple component central dyslexic syndromes. In M. Coltheart, K. Patterson and J.C. Marshall (Eds.) Deep Dyslexia, London: R.K.P.

251. Shallice, T., Warrington, E.K. and McCarthy, R. (1983) Reading without semantics. Quarterly Journal of Experimental Psychology, 35A, 111-138.

252. Shankweiler, D., Liberman, I.Y., Mark, L.S., Fowler, D.A. and Fisher, F.W. (1979) The speech code and learning to read. Journal of Experimental Psychology: Human Learning and Memory, 5, 531-545.

253. Shepp, B.E., Barrett, S.E. and Kolbet, L.L. (1987) The development of selective attention: holistic perception versus resource allocation. Journal of Experimental Child Psychology, 43, 159-180.

254. Shepp, B.E. and Swartz, K.B. (1976) Selective attention and the processing of integral and non-integral dimensions: a developmental study. Journal of Experimental Child Psychology, 24, 279-298.

255. Shulman, H.G. and Davidson, T.C.B. (1977) Control properties of semantic coding in a lexical decision task. Journal of Verbal Learning and Verbal Behvior, 16, 91-98.

256. Siegel, L.S. (1985) Deep dyslexia in childhood? Brain and Language, 26, 16-27.

257. Siegel, L.S. and Linder, B.A. (1984) Short-term memory processes in children with reading and arithmetic learning disabilities. Developmental Psychology, 20, 200-207.

258. Singleton, C.H. (1987) Dyslexia and cognitive models of reading. Journal of the National Association for Remedial Education, Support for Learning, Vol. 2, No. 2.

259. Smith, L.B. and Kemler, D.G. (1977) Developmental trends in free classification: evidence for a new conceptualization of perceptual development. Journal of Experimental Child Psychology, 24, 279-298.

260. Snowling, M.J. (1980) The development of grapheme-phoneme correspondence in normal and dyslexic readers. Journal of Experimental Child Psychology, 29, 294-305.

261. Snowling, M.J. (1981) Phonemic deficits in developmental dyslexia. Psychological Research, 43, 219-234.

262. Snowling, M.J. (1983) A comparison of acquired and developmental disorders of reading - a discussion. Cognition, 14, 105-117.

263. Snowling, M.J., Stackhouse, J. and Rack, J. (1986) Phonological dyslexia and dysgraphia: a developmental analysis. Cognitive Neuropsychology, 3, 309-339.

264. Spache, G. (1940) Characteristic errors of good and poor spellers. Journal of Educational Research, 34, 182-189.

265. Spring, C. (1976) Encoding speed and memory span in dyslexic children. Journal of Special Education, 10, 35-40.

266. Spring, C. and Capps, C. (1974) Encoding speed, rehearsal, and probed recall of dyslexic boys. Journal of Educational Psychology, 66, 780-6.

267. Spring, C. and Perry, L. (1983) Naming speed and serial recall in poor and adequate readers. Contemporary Educational Psychology, 66, 780-786.

268. Stanford Achievement Test (1982) San Antonio, T.X.: the psychological corporation.

269. Stanhope, N. and Parkin, A.J. (1987) Further explorations of the consistency effect in word and nonword pronunciation. Memory and Cognition, 15, 169-179.

270. Stanovich, K.E. (1982) Individual differences in the cognitive processes of reading: I. word decoding. Journal of Learning Disabilities, 15, 485-493.

271. Stanovich, K.E. (1985) Cognitive processes and the reading problems of learning disabled children: evaluating the assumption of specificity. In J. Torgesen and B. Wong (Eds.) Psychological and Educational Perspectives on Learning Disabilities, New York: Academic Press, pp. 87-132.

272. Stanovich, K.E. and Bauer, D.W. (1978) Experiments on the spelling-to-sound regularity effect in word recognition. Memory and Cognition, 6, 410-415.

273. Stanovich, K.E., Cunningham, A.E. and Cramer, B. (1984) Assessing phonological awareness in kindergarden children: issues of task comparability. Journal of Experimental Child Psychology, 38, 175-190.

274. Sweeney, J.E. and Rourke, B.P. (1978) Neuropsychological significance of phonetically accurate and phonetically inaccurate spelling errors in younger and older retarded spellers. Brain and Language, 6, 212-223.

275. Taft, M. (1982) An alternative to grapheme-phoneme conversion rules? Memory and Cognition, 10, 465-474.

276. Tallal, P. (1980) Auditory temporal perception, phonics, and reading disabilities in children. Brain and Language, 9, 182-198.

277. Tanenhaus, M.K., Flanigan, H.P. and Seidenberg, M.S. (1980) Orthographic and phonological activation in auditory and visual word recognition. Memory and Cognition, 8, 513-520.

278. Tansley, P. and Panckhurst, J. (1981) Children with Specific Learning Difficulties. NFER - Nelson.

279. Temple, C.M. (1984a) New approaches to the developmental dyslexias. In F.C. Rose (Ed.) Advances in Neurology, Vol. 42: Progress in Aphasiology, New York: Raven Press.

280. Temple, C.M. (1984b) Developmental analogues to acquired phonological dyslexia. In R.N. Malatesha and H.A. Whitaker (Eds.) Dyslexia: A Global Issue, The Hague: Martinus Nijhoff.

281. Temple, C.M. (1985) Reading with partial phonology: developmental phonological dyslexia. Journal of Psycholinguistic Research, 14, 523-541.

282. Temple, C.M. (1986) Developmental dysgraphias. Quarterly Journal of Experimental Psychology, 38A, 77-110.

283. Temple, C.M. and Marshall, J.C. (1983) A case study of developmental phonological dyslexia. British Journal of Psychology, 74, 517-533.

284. Theios, J. and Muise, J.G. (1977) The word identification process in reading. In N.J. Castellan, D.B. Pisoni and G.R. Potts (Eds.) Cognitive Theory (Vol 2), Hillsdale, N.J.: Erlbaum.

285. Thomas, M.M. (1977) Two schools. Dyslexia Review, 18, 20-22.

286. Thompson, G.B. (1986) When nonsense is better than sense: non-lexical errors to word reading tests. British Journal of Educational Psychology, 56, 216-219.

287. Tizard, J. (1972) Children with Specific Reading Disabilities. London: HMSO.

288. Torgesen, J.K. (1975) Problems and prospects in the study of learning disabilities. In E.M. Hetherington (Ed.) Review of Child Development Research (Vol. 5), Chicago: University of Chicago Press.

289. Torgesen, J.K. (1978) Performance of reading disabled children on serial memory tasks: a review. Reading Research Quarterly, 19, 57-87.

290. Torgesen, J.K. and Houck (1980) Processing deficiencies of learning disabled children who perform poorly on the digit span test. Journal of Educational Psychology, 72, 141-160.

291. Treiman, R. (1984) Individual differences among children in spelling and reading styles. Journal of Experimental Child Psychology, 37, 463-477.

292. Treiman, R. (1985) Phonemic awareness and spelling: children's judgements do not always agree with adults. Journal of Experimental Child Psychology, 39, 182-201.

293. Treiman, R. and Baron, J. (1983) Phonemic analysis training helps chidren benefit from spelling-sound rules. Memory and Cognition, 11, 382-389.

294. Treiman, R. and Hirsh-Pasek, K. (1985) Are there qualitative differences in reading behavior between dyslexic and normal readers? Memory and Cognition, 13, 357-364.

295. Vellutino, F.R. (1979) Dyslexia. Cambridge, Mass: MIT Press.

296. Venezky, R. (1970) The Structure of English Orthography. The Hague: Mouton.

297. Wagner, R.K. and Torgesen, J.K. (1987) The nature of phonological processing and its causal role in the acquisition of reading skills. Psychological Bulletin, 101, 192-212.

298. Warrington, E.K. (1967) The incidence of verbal disability associated with reading retardation. Neuropsychologia, 5, 175-179.

299. Waters, G.S., Seidenberg, M.S. and Bruck, M. (1984) Children's and adults use of spelling-sound information in three reading tasks. Memory and Cognition, 12, 293-305.

300. Wechsler, D. (1974) Wechsler Intelligence Scale for Children (revised edition). New York: Psychological Corporation.

301. Wepman, J.M. (1958) The Auditory Discrimination Test. Chicago: Language Research Associates.

302. Wide Range Achievement Test. (1978) Wilmington, D.E.: Guidance Associates of Delaware, Inc.

303. Wing, A.M. and Baddeley, A.D. (1980) Spelling errors in handwriting: a corpus and a distributional analysis. In U. Frith (Ed.) Cognitive Processes in Spelling, London: Academic Press.

304. Zangwill, O.L. and Blakemore, C.B. (1972) Dyslexia - reversal of eye movements during reading. Neuropsychologia, 10, 371.

305. Zifcak, M. (1981) Phonological awareness and reading acquisition. Contemporary Educational Psychology, 6, 117-126.

APPENDIX 1

Experiment 1(a)

IRREGULAR WORDS		REGULAR WORDS	
High Frequency	Low Frequency	High Frequency	Low Frequency
both	touch	best	stuck
great	deaf	green	gate
heard	pint	bring	pest
shall	wool	still	dust
knew	lose	strong	luck
break	aunt	stick	wake
does	bury	door	gang
come	laugh	take	treat
build	doll	dance	base
gone	sew	kept	rub
bowl	soul	turn	mile
love	sword	fine	spade
foot	prove	tune	spear
blood	glove	along	slate
bread	broad	able	dive

APPENDIX 2

Non-Words and Words (Experiment 1(b))

Non-Words	Words
floon	floor
gouse	house
mun	man
doy	boy
poad	road
nater	water
cag	car
fape	face
chold	child
noor	door
heam	head
pand	hand
schoom	school
charch	church
foop	food
cimy	city
streed	street
boak	book
moman	woman
ede	eye
doney	money
foom	room
garl	girl
fime	fine
toble	table

APPENDIX 3

Johnston et al.'s Materials (Experiment 3)

Pseudohomophones		Non-words	
loe	wotch	coe	cotch
hoase	teech	loase	spreed
bair	gole	nair	brode
wosp	bild	gosp	brise
moove	bloan	doove	doan
layd	blud	sayd	blum
gon	wosh	bon	mosh
luv	saive	druv	haive
poast	oan	loast	goan
woz	wurd	hoz	lurd
hoam	gore	soam	proe
flud	boath	brud	moath

APPENDIX 4

Patterson's (1982) Nonsense Words (Experiment 4(ii))

Pseudohomophones	Non-Words
wun	murld
leke	barl
waid	hefe
ahms	brait
braik	rie
soal	rild
peese	gaks
boaled	porce
fraze	dode
horl	flure
hoal	bol
woar	dake
floo	korp
chuze	ploo
ile	trude
brooze	brone
taks	mobe
throan	phroo
stawk	wute
bair	dort

APPENDIX 5

Temple and Marshall's (1983) Non-Words (Experiment 4(iii))

Pseudohomophones	Non-Words
harf	marf
moov	toov
scule	scuge
riste	niste
wissil	vissil
wond	rond
roze	loze
grene	grele
shoo	spoo
schowt	scort
coff	zoff
wich	fich
graip	fraip
shef	sheb
fite	fide
ankor	antor
flore	flere
blud	glud
heer	heeb
apil	opil
kuburd	nuburd
lofe	tofe
deff	beff
korde	dorde

APPENDIX 6

Experiment 4(iv) Simple Non-Words

rop

wut

teg

fot

lom

mun

keb

vin

poy

yab

lat

nog

nem

lub

ged

tut

kun

dup

lig

sif

APPENDIX 7

Odd Word Underlined (Experiment 6)

Series 1:	bud,	bun,	bus,	rug
	tip,	pig,	pip,	pit
	hid,	hit,	lip,	him
	peg,	bed,	pen,	pet
	log	loss,	lot,	cod
	pad,	man,	mat,	mad
Series 2:	dot,	cot,	pot,	bat
	nod,	red,	fed,	bed
	fun,	gun,	pin,	run
	lit,	cat,	bit,	fit,
	name,	game,	same,	home
	bin,	men	hen,	ten
Series 3:	hat,	sat,	pat,	bad
	job,	hop	top	pop
	pin	win	sit,	fin
	weed,	peel,	need,	deed
	hard,	yard,	card,	farm
	moon,	root,	hoot,	boot

APPENDIX 8

Experiment 7, Task 4

Test 1	Test 2	Test 3
piglet	some	brint
today	meat	arbyle
postman	heart	roldeg
outside	goat	maren
asleep	heat	blonce
belong	soon	remanter
understand	father	porle
carpet	soup	plingy
begun	dome	temeff
upon	mean	lesork
without	bather	argoster
bedroom	door	blupess
everyone	heather	scatle
inside	bean	ipeng
careless	carrot	sifen

APPENDIX 9

Experiment 8(a) Stimuli Used in Visual Rhyme Judgement Task

Type 1	Type 2	Type 3	Type 4
Rhyming and orthographically different pairs	Rhyming and orthographically similar pairs	Nonrhyming and orthographically different pairs	Nonrhyming and orthographically similar pairs
coal pole	need weed	best card	wash cash
pond wand	join coin	soon stay	both moth
hawk walk	fish wish	rich book	bowl howl
rude food	bang hang	boil safe	lost post
peer near	back sack	king nice	word pork
come plum	pink sink	hard wish	done cone
rose goes	fall ball	feel been	bead dead
bull wool	heat beat	fill care	harm warm
farm calm	snow blow	play shot	dull pull
head shed	miss kiss	club pile	hoot foot
moan bone	hide wide	glad limp	nose lose
talk fork	bite kite	must hard	fear wear
been clean	town down	rang milk	mood good
fuse news	gate late	ripe trip	tone gone
soap hope	take bake	shut send	love move
dare air	drip grip	four sick	wood blood

APPENDIX 10

Experiment 8(a) Stimuli Used in Visual Recognition Memory Task

Condition A

Cue	Target	Phonologically Similar Foil	Irrelevant Foils	
cone	done	own	gaze	blur
tone	gone	sown	half	grey
foot	hoot	put	left	moon
wear	fear	hair	lace	itch
pork	work	chalk	horn	pike
warm	harm	form	mask	lump
bead	dead	heed	loop	halt
post	lost	toast	fail	each
bowl	howl	mole	free	bolt
both	moth	oath	pest	lend
wash	cash	posh	yarn	cage
lose	nose	dues	jerk	camp

Condition B

Cue	Target	Orthographically Similar Foil	Irrelevant Foils	
dare	air	are	what	tape
bone	moan	one	slab	hush
wool	bull	fool	sort	they
come	plum	dome	real	stab
near	peer	pear	time	rock
food	rude	hood	puff	torn
goes	rose	does	pipe	kept

APPENDIX 11

Experiment 9(a) Stimuli Used in Auditory Rhyme Judgement Task

Type 1 Rhyming and orthographically different pairs	Type 2 Rhyming and orthographically similar pairs	Type 3 Nonrhyming and orthographically different pairs	Type 4 Nonrhyming and orthographically similar pairs
coat note	rice mice	twin dish	leaf deaf
rule pool	wing ring	wife side	gold wolf
hole goal	bend mend	once path	come home
made laid	sold cold	thin rope	want pant
suit boot	burn turn	tent fast	cost host
hate wait	kick pick	cage bell	bear year
glue flew	song long	stop tool	barn warn
size pies	sand hand	fire step	push rush
hurt dirt	born horn	skip help	ward hard
true drew	lift gift	game soup	doll roll
seat feet	half calf	boat trim	worm form
mean seen	cool fool	take tree	dive live
toad code	dark park	book hunt	bush hush
gear beer	find kind	wise swin	give hive
shoe chew	line mine	tank sing	full dull
bird word	tape cape	roof frog	base vase

APPENDIX 12

Experiment 9(a) Stimuli Used in Auditory Recognition Memory Task

Condition A

Cue	Target	Phonologically Similar Foil	Irrelevant Foils
warn	barn	born	grip roof
push	rush	whoosh	dent twig
host	cost	roast	corn spun
bear	year	care	chin vest
want	pant	font	heel they
home	come	foam	jeep arch
leaf	deaf	beef	lick goat
roll	doll	pole	mess bank
ward	hard	cord	link fort
worm	form	term	hose drip
give	hive	sieve	corw surf
vase	base	cars	bike film

Condition B

Cue	Target	Orthographically Similar Foils	Irrelevant Foils
seat	feet	great	boss chip
boot	suit	soot	drag germ
word	bird	lord	heap lark
toad	code	broad	bran left
shoe	chew	foe	cash noon
gear	beer	pear	need rock
size	pies	graize	much brim