AN INFORMATION PROCESSING APPROACH TO THE ASSESSMENT AND REMEDIATION OF DEVELOPMENTAL DYSLEXIA

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ABSTRACT

Remediation programmes were devised and implemented for two developmental dyslexics. Extensive pre-therapy psycholinguistic assessment determined the developmental stage at which their acquisition of reading skills had arrested. Subject DF had failed to develop orthographic skills, his pattern of performance resembled that of surface dyslexics. Subject SP indicated arrest at the logographic stage so his performance was similar to that of phonological dyslexics. Remediation focused on development of the strategy the subject had failed to acquire. The efficacy of remediation was investigated employing a single subject case study incorporating a crossover design with multiple baseline and repeated pre- and post-therapy measures. Both subjects indicated significant positive effects of therapy which could only be ascribed to the treatment. DF showed no generalisation of these effects and did not appear to alter his reading strategy. SP did indicate generalisation of the effects of therapy accompanied by changes in reading strategy. Theoretical explanations and practical implications of the results are discussed.

DECLARATION

I declare that this dissertation is my own, unaided work. It is being submitted for the Degree of Master of Arts in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

Y Broom

18th day of November, 1991

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PREFACE

The unexpected and persistent failure of a substantial proportion of children to acquire appropriate reading skills has interested both psychologists and educationalists for many years (Ellis, 1985). The majority of studies in this area have attempted to identify concomitant cognitive deficits which might afford a causal explanation for specific reading difficulties. Some of this research into the underlying causes of dyslexia was motivated by the need to help these children overcome their difficulties. A variety of teaching strategies has been applied to remediate developmental dyslexia. However, there have been few controlled investigations of their efficacy, and even fewer theoretically motivated explanations of their effects (Hulme, 1987).

The lack of theoretical explanations of the deficits implicated in developmental reading disorders and of the effects of their treatment reflected the absence of coherent theories of reading prior to the 1970's. In the last twenty years information processing models of competent reading have been proposed (Ellis & Young, 1988). These have lead to developmental models of the acquisition of reading skills such as those proposed by Frith (1985) and Seymour (1987). In the light of these models of the normal process of reading acquisition, it became possible to identify, and explain the characteristic patterns of reading performance associated with various types of developmental dyslexia (Ellis, 1984; Seymour, 1986; Snowling, 1987). While the model based assessment of individual developmental dyslexics has been well documented, this has not been the case for model-based studies of remediation.

In the present study a model based assessment was conducted of

two developmental dyslexics to determine their processing strategies and identify their stage of acquisition of reading skills. Individual remediation programmes were devised and implemented for each of the subjects. The efficacy of these programmes was determined and their practical and theoretical implications discussed. In Chapter 1 the theoretical background to the study is presented. This includes a review of the developmental models of reading acquisition as well as the models of skilled, competent reading, from which they evolved. Parallels are drawn between the patterns of reading performance shown on a psycholinguistic assessment battery by acquired and developmental dyslexics. Remediation studies which have been conducted with acquired dyslexics are discussed and issues relating to the methodology of such studies are introduced. This leads into a discussion of the aims present study.

Chapter 2 details the methodology of the study. The selection of subjects, assessment materials and procedures are reported, in addition to the design of the remediation section and the incorporated control test materials. The following chapter deals with the case histories and assessment of the two subjects: DF whose performance resembled that of a surface dyslexic, and SP who performed like a phonological dyslexic on the assessment tasks.

Chapter 4 focuses on the remediation of the two subjects. For each subject, details of the remediation programme, its method of implementation and results are related. Each case study concludes with a discussion of the results of remediation. Chapter 5 extends the discussion of the results of the study, advances theoretical explanations and considers the implications for teaching children with specific reading difficulties.

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CHAPTER 1

1.0 INTRODUCTION

The ability to read is vitally important in modern society. Reading is a complex cognitive skill involving the processing of written information. Such a complex skill requires the integrated functioning of many sub-skills. Should any of these fail to develop adequately, the individual's reading ability may fall below expectation. Although the majority of children learn to read without any difficulty, there is a substantial minority who experience unexpected difficulty in acquiring written language skills (Rodgers, 1983; Rutter, Tizard & Whitmore, 1970; Rutter & Yule, 1975; Yule, Rutter, Berger & Thompson, 1974).

Developmental dyslexia (Ellis, 1984; Snowling, 1987) is one of the terms used to refer to the condition in which an individual of average intelligence fails to attain an expected level of reading ability, in spite of adequate educational and social opportunities. Developmental dyslexia was once considered to be a unitary condition, with one underlying deficit giving rise to common symptoms in all cases (Ellis, 1984, 1985; Marshall, 1984). The influential work of Boder (1973) established three sub-types of developmental dyslexia. With the subsequent introduction of information processing models of competent reading, dyslexia was viewed as a deficiency in one of the processing modules or in the connections between them (Marshall, 1984). This approach, therefore, admitted many types of developmental dyslexia, the heterogeneity being "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, p.46).

1.1 A Functional Model of Language Processing

Cognitive neuropsychologists have proposed a functional model of normal adult language processing, based largely on evidence from patients with acquired language disorders (Coltheart, 1987; Ellis & Young, 1988). This model (see Appendix 1) indicates two main routes for reading, a lexical/ whole-word/ direct route and a non-lexical/ phonological/ indirect route. Competent reading requires that both routes are available. The lexical route is appropriate for reading words with which the subject is familiar, since visual representations of these words are stored in the Visual Input Lexicon. This route is not appropriate for reading unfamiliar items such as orthographically legal nonsense words which are not represented in the Lexicon. The non-lexical route is appropriate for reading both familiar and unfamiliar items provided they conform to the rules of grapheme-to-phoneme conversion. This route is not successful for decoding items containing unusual or highly irregular grapheme-phoneme correspondences. Such words are frequently encountered in the English language.

Impaired functioning of a component in one route leads to reliance on the other. Surface dyslexia refers to acquired disorders in which the direct route for reading is impaired. In cases of acquired surface dyslexia, for example patient JC in Marshall and Newcombe (1973), reading relied on a phonological strategy with consequential difficulty reading irregular words and a preponderance of 'regularisation' errors. Phonological dyslexia refers to acquired disorders in which the phonological route for

reading is impaired, for example patients RG of Beauvois and Dérouesné (1979) and WB in Funnell (1983). These cases showed reliance on the lexical route for reading with consequential difficulty reading unfamiliar words and non-words.

The model of skilled language processing shown in Appendix 1 indicates that both the lexical and phonological routes for reading involve more than one functional module and the connections between them. Impairment to any of these may cause breakdown of the processing route. Thus, the syndromes of surface and phonological dyslexia have been fractionated to such an extent that their usefulness has been questioned (Ellis, 1987).

The model in Appendix 1 has been the basis for interpretation and establishment of the syndromes of acquired dyslexia, which, in turn, have been used to establish parallel developmental analogues (Coltheart, Masterson, Byng, Prior & Riddoch, 1983; Marshall, 1987; Mitterer, 1982; Seymour & MacGregor, 1984; Temple, 1984). Cases of developmental phonological dyslexia are reported by Temple and Marshall (1983), Seymour and MacGregor (1984), Campbell and Butterworth (1985), Snowling, Stackhouse and Rack (1986), Funnell and Davison (1989) and Snowling and Hulme (1989). Cases of developmental surface dyslexia have been reported by Coltheart et al. (1983), Seymour (1986) and Goulandris and Snowling (1991).

Snowling (1983), Frith (1985) and Seymour (1987) maintained that a developmental model of the acquisition of literacy is a more appropriate framework for the interpretation of developmental dyslexia than a model of skilled reading. Seymour (1987) pointed out that the acquisition of an impairment to one module of a fully developed language processing system would not be expected to affect the functioning of other modules. However, in the case of

developmental disorders where the acquisition of competence at one stage depends on transmission of data from a previous stage, impairment of development of that previous stage will prevent development of subsequent skills. He concludes "it seems likely that the relationship between acquired and developmental dyslexic sub-types will be one of general similarity rather than of exact correspondence" (Seymour, 1987, p.353).

1.2 Models of the Development of Literacy Skills

Frith (1985) proposed a developmental model of the acquisition of reading and spelling skills which ultimately results in the skills and structures described in the model of adult processing shown in Appendix 1. Frith's developmental information processing model was based on the earlier, empirically supported cognitive developmental model of Marsh, Friedman, Welch & Desberg (1981). According to Frith's model, reading development proceeds by successive acquisition of three processing strategies. Primarily, the child develops visual logographic skills which focus on salient features of words and allow instant recognition of known words from a limited set of responses. This is followed by acquisition of alphabetic skills which permit sequential decoding of unfamiliar words by applying knowledge of individual phonemes and their corresponding graphemes. Finally, visual orthographic skills develop which allow instant word recognition based on a systematic analysis of words into orthographic units. These orthographic units are conceived as abstract letter sequences approximately corresponding to morphemes.

The sequence of acquisition of these three phases is apparent not only in the development of word recognition (reading) but also in the development of word production (writing). The model

postulates an interaction between reading and writing skills so that each phase of skill development is divided into two steps (see Figure 1 in Appendix 2). The logographic strategy appears first for reading and then is transferred to spelling. The alphabetic strategy first becomes apparent in spelling and is later transferred to reading. The orthographic strategy is primarily available for reading and subsequently transferred to spelling.

Although Frith's model clearly specified distinct stages through which the acquisition of reading and spelling proceed, it was vague about the exact relationship between these stages. This model offered no explanation as to why it should be necessary to establish a logographic strategy prior to development of an alphabetic strategy, and, while it was suggested that the orthographic stage developed by merging of the logographic and alphabetic strategies, how this might occur was not elucidated. In addition, Frith did not specify each stage in terms of a modular information processing system, so the relationship between the developing structures and those of the ultimate, skilled model were not stipulated.

This was achieved in the subsequent model of the development of literacy proposed by Seymour and MacGregor (1984), and Seymour (1987). This model, shown in Figure 2 of Appendix 2, resembled Frith's in that it identified the logographic, alphabetic and orthographic processing strategies and, also, resulted in a model of skilled reading, shown in Figure 1 of Appendix 3, functionally corresponding to the model in Appendix 1. However, the models differed in that Seymour addressed the issue of the relationship between the stages. He allowed the co-existence of a separate logographic phase with either an alphabetic or an orthographic

phase. This was possible because his model included a logographic lexicon with direct access to semantic information in parallel with an alphabetic lexicon which evolves into an orthographic lexicon. Although this model clearly stated that orthographic development depended on prior establishment of an alphabetic strategy, it did not make any predictions regarding the relationship between the logographic lexicon and orthographic development, nor about the order in which the alphabetic and logographic strategies develop.

A later version of this model (Seymour, 1990b) was the 'dual foundation' model, Figure 2 in Appendix 3. This model took cognisance of recent research suggesting that children may learn to read alphabetically without passing through a logographic stage (Stuart & Coltheart, 1988; Seymour, 1990b). Teaching strategies to which the child was exposed may have masked the parallel development of early logographic and alphabetic strategies, so earlier models to postulate the primacy of a logographic stage. The dual foundation model indicated that establishment of both the logographic and alphabetic lexicons are necessary but not sufficient for development of the orthographic lexicon, by which skilled reading proceeds. It elucidated how the merging of logographic and alphabetic information results in formation of the orthographic lexicon.

The elaboration of developmental models of the acquisition of reading and spelling skills, provides a framework within which explanations of the failure to develop these skills may be formulated. Both Frith (1985) and Seymour (1987) proposed that reading acquisition occurs in a sequence of stages. Each stage being characterised by predominant reliance on either a phonological or a lexical strategy for reading (Ellis, 1984). According to both of these models, the developmental dyslexic fails to progress

through the stages in the normal manner so his reading age falls behind his chronological age. This was supported by Baddeley, Logie and Ellis (1988) who found that developmental dyslexics adopted similar strategies for reading to normal children of equivalent reading age. This suggests that developmental dyslexia represents a delay in the development of written language processing skills.

Frith (1985, p.304) defined developmental dyslexia as "persistent failure to advance to the next step in the normal acquisition process". She allowed that, although progress to the next developmental stage may be arrested, the child's reading age may continue to improve as a consequence either of improvement in the skills which he has managed to acquire or the development of deviant compensatory strategies. This implied that, while the processing strategies of a developmental dyslexic may resemble those of younger children, they may not be identical. There may be a qualitative similarity but quantitative differences between the reading performance of normal and dyslexic children of similar reading age.

In terms of Seymour's dual foundation model, developmental dyslexia results from failure to develop an orthographic lexicon. This may occur either because of phonological impairment which prevents alphabetic development or because of logographic impairment which prevents establishment of the visual lexicon. Both models agree that the acquisition of both visual and phonological strategies are necessary for skilled reading (Ellis, 1985), especially of a language such as English which has a high proportion of irregular words that do not conform to the rules of grapheme-to-phoneme conversion (Venezky, 1970; Wijk, 1966).

1.3 Model-based Assessment of Reading Disorders

The ultimate result of the developmental process represented by the stages of Frith and Seymour's models is the adult model of language processing shown in Appendix 1. An assessment of a dyslexic subject, based on this adult model, can identify those modules and their connections which have been acquired as well as those which have failed to develop. The cognitive neuropsychological approach has established the psycholinguistic method for assessment of language processing abilities. This assessment is based on the properties of language such as the regularity, imagebility, frequency of occurrence and lexicality of words. Controlled variation of such properties identifies language processing strategies and locates language processing deficits, whether acquired or developmental, within the appropriate information-processing model.

In the assessment of developmental dyslexics, comparison of the pattern of functioning with the stages of the developmental models can identify whether the subject's development is delayed or deviant. In addition, comparison of the subject's performance with that of younger readers with a similar Reading Age indicates the severity of the delay and the nature of any deviance.

1.4 Remediation of Reading Disorders

Ultimately the interest in dyslexia should focus on determination of appropriate intervention to help the dyslexic overcome his/her difficulties and establish functional reading skills, but "strangely, the literature on dyslexia has focused more upon its associated factors than upon its remediation," (Snowling, 1987,

p.147). A wide variety of teaching strategies have been employed over the years to treat the symptoms of developmental dyslexia (Hulme, 1987). However, in the absence of a model of the reading process, evaluation of the effects of the treatments and explanation of these effects was not possible, and, "the effectiveness of many well-ingrained teaching methods has not been as rigorously assessed as it might have been," (Ellis, 1985, p.201).

With the elaboration of the information processing models of skilled reading shown in Appendix 1, it became possible to assess acquired dyslexics, to establish the precise stage at which breakdown of their reading skills occurred and to determine which skills were intact and which required rehabilitation. This model-based approach to assessment and rehabilitation has been applied to cases of acquired disorders such as deep dyslexia (de Partz, 1986), dysgraphia (Behrmann, 1987; Hatfield, 1983) and aphasia (Byng & Coltheart, 1986).

The models of the development of reading skills, discussed above, also afford the opportunity of assessing developmental dyslexics to determine which strategies they have acquired and which have failed to develop appropriately. Once the individual's deficits in processing have been identified there are two alternatives regarding any remediation programme: either compensation or rehabilitation (Byng & Coltheart, 1986; Howard & Hatfield, 1987). Compensation implies that the deficit is permanent so strategies which are not impaired are developed to compensate for those which cannot function. In relation to developmental dyslexia this approach would amount to focusing on the child's strengths, with no attempt to develop those skills with which the subject had difficulty. Rehabilitation refers to treatment which aimed at

developing or restoring the impaired function. In relation to cases of acquired disorders this implies regaining a premorbid level of functioning. In developmental cases where a skill has not been acquired, it implies focusing on the child's weakness in an attempt to develop that skill. Developmental models of reading, emphasise the dependence of orthographic development on prior logographic and alphabetic development, thus these models indicate that the appropriate approach to the remediation of developmental dyslexia is rehabilitation rather than compensation.

In contrast to the large number of reported model-based assessments of developmental dyslexics, (see Seymour, 1990b), only one model-based study of remediation has recently been reported by Seymour (1990a). In this paper Seymour reported preliminary results from part of a longitudinal investigation into the effects of cognitive intervention based on his dual foundation model, on cases of developmental dyslexia. A cognitive assessment procedure based on reading and spelling of words and non-words, and incorporating measures of reaction times for reading single words, was employed to identify the processing strategies available to the two subjects. It was determined that the two subjects were arrested at different stages in their acquisition of reading skills. Although both had failed to acquire orthographic strategies, one exemplified phonological dyslexia while the other exemplified surface or morphemic dyslexia. An intervention programme was devised which aimed to establish an orthographic lexicon, and the same programme administered to both subjects, even though their reading strategies were quite different. The progress of the subjects was monitored by repeated cognitive assessment, however the study did not incorporate adequate control mechanisms to allow the efficacy of the

intervention to be unequivocally determined.

Teaching strategies have been applied to the remediation of developmental dyslexia since the beginning of this century, and, in spite of the paucity of theoretically grounded explanation of their effects, their success has been established (Hulme & Bradley, 1984; Hulme, 1987; Snowling, 1987). Two features of successful techniques have been identified, the teaching of phonics (Naidoo, 1981; Gittelman & Feingold, 1983) and multisensory teaching (Fernald, 1948; Hulme, 1981). A combination of these techniques was incorporated into the widely used 'simultaneous oral spelling' method, initially developed by Gillingham and Stillman (1956) and employed by Bradley (1981), Hulme and Bradley (1984) and Bradley and Bryant (1985).

In spite of the fact that some of these teaching strategies have proved very successful, it would be surprising if one strategy was effective with all subjects, considering the heterogeneous nature of the disorder (Ellis, 1985; Patterson, Marshall & Coltheart, 1985). Mattis (1981) proposed differential treatment programmes for the different syndromes of dyslexia identified by Boder (1973). Unfortunately these syndromes, themselves, are unlikely to be homogeneous so application of a particular teaching strategy to a group of subjects is unlikely to be equally effective for all members of the group. This highlights the problem of conducting group studies to investigate the efficacy of remediation. If some subjects respond positively while others do not, the effects of the treatment are confounded, because of the heterogeneity of the group.

Group studies, therefore, are not appropriate for research on the assessment and rehabilitation of heterogeneous syndromes, and

single case studies are recommended (Caramazza & McCloskey, 1988; Howard, 1986; Seymour, 1990b; Wilson & Baddeley 1988). If individual dyslexic subjects are assessed to determine the nature of their reading difficulties, the efficacy of a specific remediation programme could be ascertained by means of a longitudinal case study which incorporated repeated reassessment. Single case studies of rehabilitation have been reported for acquired disorders (Behrmann, 1987; Byng & Coltheart, 1986; de Partz, 1986). Although Seymour (1990a) has recently reported single case studies of remediation of developmental disorders previous studies (for example Hulme & Bradley, 1984) were group studies.

Howard & Hatfield (1987) review a variety of single subject research designs. They assert that a study concerned with the evaluation of rehabilitation must be able to distinguish between: the specific effects of the therapy; the effects of spontaneous improvement, that would have happened without any intervention; and the general effects of being involved in therapy, such as support, interest and encouragement (Howard & Hatfield, 1987; Howard & Patterson, 1989). If subjects are tested repeatedly there may also be effects of pre-test sensitisation (Byng & Coltheart, 1986). In addition, the effects of treatment may either: lead to improvement in all tasks of language processing; or lead to specific improvement in the items or task being treated and not generalise to untreated items or tasks (Howard, 1986).

1.5 Aims of the Study

The aim of the present study was to apply a model-based approach to the assessment and remediation of individual cases of developmental dyslexia. Psycholinguistic assessments (Doctor & Klein, 1986) of

developmental dyslexics, were conducted to find two subjects who exemplified the two different pre-orthographic strategies for reading, one who had failed to develop alphabetic skills and another who had impaired visual processing. Due to the specific nature of the subjects' reading problems, differing remediation programmes were devised which aimed to rehabilitate their specific deficits, rather than compensate for them. The efficacy of these programmes was investigated.

There are certain conditions which must be fulfilled before claims can be made about the efficacy of any remediation programme (Howard & Patterson, 1989). Firstly, a stable baseline should be established prior to intervention. Secondly, if the underlying process has been affected, the effects should generalise to a related task. Thirdly, there should be no transfer of effects to unrelated processing tasks. Control and assessment tasks were conducted at appropriate stages of the study to permit evaluation of each programme both in terms of its specific effect on the treated items, and the extent to which this effect generalised to untreated items and to the underlying processing deficit.

1.6 Hypotheses

1.6.1 The specific remediation programme devised for each subject, will improve his ability to read treated items.

1.6.2 The effects of treatment will generalise to the underlying processing strategy, leading to improved performance on both reading untreated items and the related processing task.

1.6.3 Treatment will not affect performance on any of the unrelated processing tasks.

CHAPTER 2

2.0 METHOD

2.1 DESIGN

A single subject case study design was implemented so the specific deficits of the two subjects could be identified and the effects of a specific treatment on those deficits were evaluated. The case studies were divided into two sections: assessment and remediation. The assessment section involved description of the individual subjects. In the remediation section a single subject research design was implemented.

The Dependent Variable in this design was the efficacy of therapy. Two aspects of the Dependent variable were measured:

(i) The efficacy of therapy on the treated items was measured by the difference in performance on the treated and untreated items from pre-therapy to post-therapy.

(ii) The efficacy of therapy on the underlying processing strategy, or the extent to which the effects of therapy generalised to a related processing task, were measured by the difference between pre-therapy and post-therapy performance on the untreated, related language processing task.

The Independent Variable in this design was the presence or absence of therapy. Therapy involved training on items which were either words or grapheme-to-phoneme correspondences. In the First Phase of Therapy one group of training items was treated while the other acted as a control group. In the Second Phase of Therapy the roles of the two groups of items were reversed.

The single subject design permitted control of extraneous variables inherent to the subjects, since each subject was his own control. Individual differences in, for example level of reading skills or stage of reading development, did not affect the results of the study as they were constant over both levels of the Independent variable, ie. Phase One and Phase Two of therapy.

To allow the effects of therapy to be distinguished from potentially confounding effects such as spontaneous improvement, involvement in therapy and repeated testing, the design incorporated the following features:

- a multiple baseline (Howard & Hatfield, 1987) involving three pre-therapy administrations of words of the type to be remediated and repeated measures of performance on unrelated processing tasks. If performance is stable over this period then spontaneous improvement is not occurring, neither is there a general effect of being in therapy, nor of pre-test sensitisation. If performance does improve, it is not possible to distinguish between these effects using a single baseline. However, when multiple baselines are established with unrelated processing tasks before, during and after therapy, these effects can be separated from the effect of therapy.

- a crossover design (Howard & Hatfield, 1987). The training items, either words or grapheme-to-phoneme correspondences, to be remediated were randomly assigned to two groups. In the First Phase of Therapy, one group of items was treated while the other items comprised a control group. In the Second Phase of Therapy the groups were reversed. If performance on the treated items increased more than on the untreated items then there were specific effects of treatment. This design also allows determination of the permanence

of the effects of treatment, as performance on the group of items treated first, is determined over the second treatment phase. A reduction in performance would indicate that the effects of therapy were not stable.

- Pre-therapy and Post-therapy Tests (Byng & Coltheart, 1986). The difference between performance indicates the effect of therapy. The inclusion of two presentations at both these stages allows determination of the effects of pre-test sensitisation. If performance increases from one pre-test to the next, and from one post-test to the next, this cannot be due to the effects of therapy, since there was none in these periods, so it must be due to pre-test sensitisation.

- a language processing task related to the treated task was included to allow determination of the generalisation of the effects of therapy. Increased performance on this related task over the period of the study indicates that the therapy was effective in remediating the common, underlying processing difficulties and not just in improving performance on the items selected for remediation.

2.2 SUBJECTS

Subjects were selected from pupils attending an English medium, full-time remedial primary school. A 'screening test' was administered to each of the 36 pupils in Standards 3, 4 and 5 to to determine their reading strategies. Two Standard 3 boys were selected as subjects: DF, who adopted a phonological strategy for reading; and SP, who adopted a visual strategy. Both subjects had and average IQ, a standard reading age at least two years below their chronological age, no history of a primary emotional disturbance, and their home language was English.

Table 2.1 shows the chronological age, standard reading age (measured on the Burt Sight Reading Test), standard comprehension age (measured on the Neale Analysis of Reading) and standard spelling age (measured on the Daniels and Diack) for both subjects. The subjects' Verbal, Nonverbal and Total IQ measures, as determined on the SSAIS are also shown.

Table 2.1

Chronological Age, Standard Reading, Comprehension and Spelling Ages and IQ for each Subject.

	DF	BP
Chronological Age	11.42	11.17
Sight Word Reading Age (Burt)	9.42	8.75
Comprehension Reading Age (Neale)	9.50	9.42
Spelling Age (Daniels & Diack)	9.00	8.25
Verbal IQ	114	111
Nonverbal IQ	116	119
Performance IQ	117	117

(Age in years)

Two control groups of 'normal readers' were selected for comparison with the experimental subjects on the Assessment tests. Each group contained 25 subjects, both male and female, whose Reading Age (measured on the Schonell (R1) Reading Test) was within six months of their Chronological Age. Table 2.2 summarises the information on the control groups. Subject DF's Reading Age was within the range of Group A while subject SP's Reading Age was within the range of Group B.

Table 2.2

Chronological and Reading (Schonell) Ages for Control Groups

		Group A	Group B
Number of Subjects		25	25
Chronological Age (years)	Mean	9.27	8.34
	S.D.	0.29	0.47
Reading Age (years)	Mean	9.22	8.48
	S.D.	0.47	0.47

2.3. MATERIALS

Materials used for the selection of subjects, as well as the assessment and remediation of both subjects are discussed in this section, while those used exclusively for either subject are discussed in the Case Reports for each subject.

2.3.1 Assessment

The psycholinguistic assessment of language processing (Doctor & Klein, 1986) was used to locate subjects' processing strategies and deficits. Some of the tests in this battery were not suitable for assessment of children because they were based on the frequencies of occurrence of words in adult language. New tests were devised according to the same principles, using word frequencies from childrens' written language word counts (Carroll, Richman & Davies, 1971). In all tests which required the stimuli to be presented visually to the subject, stimuli were printed in lower case black letters on white index cards, one item per card. Scoring sheets were provided for the tester to record the subjects' responses.

Test 1 - Lexical Decision - Visual Presentation

The stimuli for Test 1 were 32 concrete nouns selected from Carroll

et al.(1971) so that 16 items had a high frequency of occurrence (between 100 and 260 per million, Mean = 157, Standard Deviation = 44.78) and 16 items had a low frequency of occurrence (between 0.30 and 4.00 per million, Mean = 1.72, Standard Deviation = 0.81). The 16 high and 16 low frequency items were divided into four groups: four, five, six and seven letter items, with four items in each group. These are shown in Appendix 4.

One non-word was derived from each word by changing the initial grapheme so that the non-word was orthographically legal and pronounceable, eg. RAIN changed to HAIN. The non-words were checked to eliminate any Afrikaans words, since the subjects were simultaneously learning to read Afrikaans as a second language.

Test 2 - Lexical Decision - Auditory Presentation

Another 32 words were selected from Carroll et al. (1971) according to the same criteria as Test 1. They were matched to the words in Test 1 for frequency and syllable length, as shown in Appendix 4. As in Test 1, 32 matching non-words were derived from the words.

Test 3 - Reading of Words and Non-words.

A further set of 32 words were selected from Carroll et al. (1971) according to the same criteria as Tests 1 and 2. They were matched to the words in Test 1 for frequency, regularity of grapheme-to-phoneme correspondence and syllable length, as shown in Appendix 4. As in Test 1, 32 matching non-words were derived from the words.

Test 4 - Reading of Regular and Irregular Words.

The stimuli included 40 Regular words whose graphemes conformed to their most common pronunciation (Berndt, Reggia & Mitchum, 1987), 40 Irregular words whose pronunciation was not readily predictable from their graphemes (See Section 3.1.3 for a more complete discussion of Regular and Irregular words). The 40 words of each type were

selected so that 20 had high frequency of occurrence (>70 per million) while 20 had a low frequency of occurrence (<10 per million) (Carroll et al., 1971). Regular and Irregular words were matched for: frequency of occurrence; imagebility; part of speech; letter and syllable length, as shown in Appendix 5.

Test 5 - Reading of Non-words

For Test 5, 40 non-words were derived from the Irregular words of Test 4 by changing the initial grapheme, ensuring that the non-word remained pronounceable and orthographically legal. Appendix 5 shows both the Irregular words and their matched non-words. Any Afrikaans words were eliminated.

Test 6 - Homophone Definition

Homophones are words with the same phonological representation but different orthographic and semantic representations, for example: RIGHT and WRITE, NOSE and KNOWS. Homophone stimuli in this test were selected so that the individual homophones had similar frequencies of occurrence in children's written language (Carroll et al., 1971), thus the stimuli included homophones such as RAW (frequency = 29,17 per million) and ROAR (frequency = 25,61 per million) but not items such as WAY (frequency = 1279 per million) and WEIGH (frequency = 28.87 per million). The homophones were classified as being either Regular or Irregular. Sixteen Regular and sixteen Irregular homophones were selected. Each homophone was matched to a non-homophone word with similar frequency of occurrence and regularity of grapheme-to-phoneme correspondence, as shown in Appendix 6.

Test 7 - Silent Tests of Phonology

The stimuli consisted of 10 pairs of Regular word Homophones eg. TACKS and TAX, 10 pairs of Irregular word Homophones eg. KNOWS and

NOSE, and 10 pairs of Non-word homophones eg. AIF and AFE. For each of the three types of stimuli, each pair of homophones was matched to another pair of non-homophones of similar frequency of occurrence and the same graphic similarity (Weber, 1970), eg. DAYS and DAZE matched DAYS and DAME. These stimuli are shown in Appendix 8.

Test 8 - Reading Aloud Items From Silent Tests of Phonology

Appendix 15 shows the 20 Regular words, 20 Irregular words and 20 Non-words which were selected from the Stimuli in Test 7 (Silent Tests of Phonology) to form Test 8.

Test 9 - Spelling Test

Appendix 7 shows the stimuli for Test 9, a shortened form of Test 6 containing 40 items, 10 Regular and 10 Irregular Homophones with their matched non-homophone words.

2.3.2 Screening Tests

The initial group of 36 potential subjects were not administered the full battery of Assessment Tests. Shortened forms of each test were devised for the purpose of subject selection. The number of stimuli in Assessment Tests 1-8 were reduced by half, ensuring that the appropriate balance and matching of stimuli was maintained.

2.3.3 Materials for Remediation.

Both subjects were presented with words to read during their remediation. Those were randomly arranged and printed in lower case script one centimetre high, in three columns, on sheets of A4 paper. Responses were recorded by the tester on scoring sheets. Each subject recorded his written work during each remediation session in an A5 exercise book.

The materials used for remediation were different for each subject

so they are discussed in detail in the Case Reports (Chapter 3, Section 3.3).

2.3.4 Materials for Control tests

(a) Related Language Processing Task

The Related Language Processing Task for DF was the modified Homophone definition sub-test of Doctor and Klein (1986). This was the same as Test 6 of the Assessment, discussed in Section 2.3.1. The Related Language Processing Task for SP was the modified sub-test of word and non-word reading Doctor and Klein (1986). This was the same as Test 3 of the Assessment, discussed in Section 2.3.1.

(b) Unrelated Language Processing Task

(i) The Test of Receptive Grammar (T.R.O.G.) (Bishop, 1982) was employed as the unrelated language processing task for both subjects. This test consists of 80 items ranging from single words to ten word, complex sentences. The items are arranged in four groups. Each group of items tests the subject's ability to comprehend an aspect of syntax, such as: single nouns, verbs and adjectives; active and passive sentences, (eg. 'the girl is pushing the horse' and 'the cow is pushed by the man'); and complex sentences with embedded clauses (eg. 'the book the pencil is on is red'). The items are spoken to the subject, who indicates comprehension of the item by pointing to one of four pictures. The pictures are chosen so that comprehension of the whole sentence is required in order to select the correct response. Responses are recorded by the tester.

(ii) The Human Sciences Research Council (HSRC) English First Language Achievement Test Subtests 3 (Reading Comprehension) for

Standard Two pupils was used as a second unrelated language processing task for both subjects. This test is in the test booklets Form A and Form B (Clark & Kritzinger, 1973a). (Although the subjects were in Standard Three, the Standard Two level of these tests was used. The Manual for Scholastic Achievement Tests (Kritzinger, 1973, p.4) advises that the Standard Three level should not be administered until completion of the Standard Three syllabus.)

In the Comprehension Test seven short passages are followed by one or more questions to test comprehension of ideas, meanings or concepts conveyed by the passage. There are four practice questions and 30 test questions. Responses are marked on the question paper.

(c) Unrelated Processing Task

The HSRC Scholastic Achievement Test in Arithmetic for Standard One, Subtest 1 (Holtzhausen & Kruger, 1973) was used as the unrelated processing task for both subjects. The Standard One level of this test was considered appropriate for the subjects by their Class teacher. The Standard Two level was considered too difficult.

2.4. PROCEDURE

The study was carried out in the following stages:

(a) Selection of subjects.

(b) Initial Psycholinguistic Assessment.

(c) Pre-therapy testing on:

- stimuli of the type to be remediated (three sessions)
- the related language processing task (two sessions)
- the unrelated language processing task (two sessions)
- the unrelated processing task (two sessions)

(d) First Phase of Therapy (three periods of remediation)

(e) Reassessment of:

- stimuli of the type remediated (treated and untreated items)
- the related language processing task
- the unrelated language processing task
- the unrelated processing task

(f) Second Phase of Therapy (three periods of remediation)

(g) Post-therapy testing of:

- stimuli of the type remediated (treated and untreated items) (two sessions)
- the related language processing task (one session)
- the unrelated language processing task (one session)
- the unrelated processing task (one session)

2.4.1 Assessment

The assessment tests were administered individually to each subject in a quiet room.

Test 1 - Lexical Decision - Visual Presentation

The items shown in Appendix 4 were randomly ordered and the cards with the items printed on were presented to the subject one at a time. Four practice items were presented first, and the correct response explained, if necessary. The subject was instructed to respond "is a word" or "is not a word". Responses were scored by the tester, on the scoring sheet shown in Appendix 9.

Test 2 - Lexical Decision - Auditory Presentation

The procedure was the same as for Test 1, except that items were presented auditorily to the subject. The scoring sheet is shown in Appendix 10.

Test 3 - Reading of Words and Non-words.

The items shown in Appendix 4 were randomly arranged and presented to the subject one at a time. The subject was instructed to read the words aloud. Responses were recorded by the tester on a scoring sheet shown in Appendix 11. The same procedure was followed for administering Tests 4 and 5. (See Appendix 5 for stimuli and Appendix 12 for scoring sheets).

Test 6 - Homophone Definition

The stimuli shown in Appendix 6 were presented in random order, one at a time. The subject was instructed to: define the word; then read the word aloud; then to name the letters of the word, in sequence, while still looking at it. Four practice examples were administered at the beginning of the test. Responses to all three sections of the test were recorded by the tester on the scoring sheet shown in Appendix 13.

Test 7 - Silent Tests of Phonology

The pairs of items shown in Appendix 8 were randomly arranged and presented to the subject one pair at a time. Four practice stimuli were presented and discussed with the subject. The subject was instructed to respond "sound the same" or "sound different", but not to read the items aloud. Responses were recorded by the tester on a scoring sheet, shown in Appendix 14.

Test 8 - Reading Aloud Items From Silent Tests of Phonology

The items of each type were randomly arranged in three sets, as indicated in Appendix 15, and presented to the subject one at a time. The subject was instructed to read the items aloud. The total time taken to read each set of items was recorded. Responses were scored by the tester on the scoring sheet shown in Appendix 15.

Test 8 - Spelling Test

The stimuli shown in Appendix 7 were presented to both subjects as a spelling to dictation task. The target word was read to the subjects. Then the word was embedded in a carrier sentence which conveyed its meaning and disambiguated the homophones. Finally the target word was repeated and the subjects recorded their written response on A4 paper.

2.4.2 Remediation

Remediation of each subject was conducted individually in a quiet room, during school hours. For each subject there were three sessions of remediation with the therapist each week, on Monday, Wednesday and Friday mornings. Each session lasted approximately twenty five minutes. The subjects were instructed to practice items from each session at home (as part of their 'homework') and, on Tuesday and Thursday, with their Class Teacher.

There were two Phases of Therapy, each consisting of three periods of remediation. On completion of each period of remediation, performance on the items remediated during that period and the appropriate control items was tested.

Details of the Procedure for Remediation were different for each subject and, therefore, are discussed in the Case Reports (Chapter 3, Section 3.3).

2.4.3 Administration of Control Tests

As mentioned in Section 2.4, control tests were administered at appropriate stages of the study.

(a) Related Language Processing Tasks

Procedure for the administration of these tests was discussed in

Section 2.4.1, since they were also administered during the assessment of subjects. The appropriate Related Language Processing Task for each subject was administered on four occasions: twice in the Pre-therapy period, once between the First and Second Phases of Therapy and once Post-Therapy.

(b) Unrelated Tasks

(i) The T.R.O.G. was administered according to the instructions in the Manual (Bishop, 1982, pp.8-14). It was administered on four occasions: twice in the Pre-therapy period, between the First and Second Phases of Therapy and Post-Therapy.

(ii) The HSRC tests of Reading Comprehension and Arithmetic were each administered to the subjects, on four separate occasions: twice in the Pre-therapy period, once between the First and Second Phases of Therapy and once Post-Therapy. These tests were administered according to the procedure in the Manual for Scholastic Achievement Tests (Kritzinger, 1973, pp.40-41) and the Manual for Scholastic Achievement Tests in Arithmetic (Holtzhausen & Kruger, 1974, pp.19-20).

CHAPTER 3

3.0 CASE REPORTS

3.1 HISTORY

3.1.1 Case 1: DF.

DF was an eleven year old, right-handed boy from an English speaking family. He had two older siblings, a sister whose academic progress was normal, and a brother who was dyslexic. DF's birth was normal and early milestones were within normal limits. DF started school at the age of 6 years 2 months. He repeated Grade One because of immaturity and unsatisfactory progress.

At age 7 years 10 months he was referred for psychological assessment because his progress remained unsatisfactory. It was determined that DF's potential level of intellectual functioning was above average. He presented with a marginal degree of Attention Deficit Disorder, and was considered 'at risk for developing specific learning difficulties later on in school'. His mental, perceptual and emotional development were immature for his chronological age, but adequate for Grade I, as were his reading and spelling skills.

At age 9 years 9 months, when DF was in Standard 1, he was referred to the Transvaal Education Department Educational Aid Centre for assessment because his scholastic progress was considered unsatisfactory. His IQ was reported to be in the high average range but reading was slow with poor comprehension and poorly developed sight word vocabulary. (Neale Analysis of Reading Ability: Rate = 8y7m; Accuracy = 8y8m; Comprehension = 7y4m.) DF subsequently attended part-time remedial classes, but this did not help him

develop age appropriate skills. The following year he was re-assessed and transferred to a full-time remedial school.

3.1.2 Case 2: SP

SP was an eleven year old, left-handed boy who was the older of two siblings. His father was Afrikaans speaking while his mother spoke English. Although SP attended an English medium school, his parents spoke both English and Afrikaans at home. His parents both attained Standard 10 level of education, and his mother obtained a Nursery School Teacher's Diploma. There was no family history of learning disabilities or psychiatric illness.

SP was born by emergency caesarian section, suffered exhaustion and jaundice, and had to be drip fed. Health after birth was good, but he had a number of ear infections. Developmental milestones were within normal limits, although he had a stutter at the age of three, which was not treated and disappeared spontaneously. He was described as a restless child who fidgeted a lot, was emotional, excitable and impulsive, with poor self confidence.

SP attended nursery school for 18 months and began formal schooling when he was 6 years 5 months. At the end of his first year in school he was referred for psychological assessment because his progress was slow and it had been recommended that he repeat Grade I. His non-verbal level of intellectual functioning was 'bright average', but his verbal level was 'average'. He presented with mixed laterality and directionality difficulties, as well as poor visual memory, auditory discrimination, blending and closure. His receptive and expressive language were poor, reading and spelling were a year below his chronological age, while arithmetic skills were average SP repeated Grade I and attended part-time

remedial education. Subsequently, he passed Grade II and Standard 1, but in April of Standard 2 transferred to a full-time remedial school.

3.1.3 Discussion

Both subjects were 11 year old males with histories of learning difficulties who attended Standard Three at a full time remedial school. Table 2.1 shows a summary of the psychometric assessment of the two subjects. Both subjects had IQs in the average range and a reading age more than two years below their chronological age, therefore they were considered dyslexic.

3.2 ASSESSMENT

The aims of the psycholinguistic assessment were: (a) to determine the reading strategies employed by the subjects; (b) to determine the stage of development of their reading skills; and (c) to identify their specific reading difficulties. The results of the psycholinguistic assessment of both subjects and their Reading Age matched control groups are summarised in Appendix 17.

3.2.1 Case 1: DF

Test 1 - Lexical Decision - Visual Presentation

To determine DF's knowledge of English orthography, his ability to recognise English words and to reject orthographically legal non-words was assessed by administering a Lexical Decision task (Test 1). DF made correct decisions for 25/32 (78%) words and for 26/32 (81%) non-words. There was no significant difference between performance on words and non-words (Chi sq.=0, d.f.=1, n.s.).

Test 2 - Lexical Decision - Auditory Presentation

On Test 2, DF made correct decisions for 31/32 (97%) words. Performance on the non-words was identical to that on words. DF performed significantly better on the auditory than on the visual form of this task (Fisher's Exact Test, p=0.0022). This discrepancy indicates that DF's poorer visual performance is not due to a general language deficiency, but to a specific reading difficulty.

Test 3 - Reading of Words and Non-words

When DF was required to read aloud a matched list of words and non-words (Test 3), he correctly read 25/32 (78%) words and 23/32 (72%) non-words. There was no significant difference between DF's ability to read words and non-words (Chi sq.=0.08, d.f.=1, n.s.). This implies that DF used a phonological strategy for reading. Had he been using a visual strategy real words would have had an advantage over non-words.

Test 4 - Reading of Regular and Irregular Words

To further determine DF's strategy for processing written stimuli, Test 4 was administered. DF's ability to read the two types of stimuli was significantly different (Fisher's Exact Test, p<0.001). He read 38/40 (97.5%) of the Regular words correctly but only 23/40 (57.5%) of the Irregular words. These results support the notion that DF read by a phonological strategy. Further evidence for this comes from the errors made on reading Irregular words. There were 14/15 (93.3%) 'regularisation' errors (Coltheart et al., 1983). These errors occur when uncommon grapheme-to-phoneme correspondences in the irregular word are pronounced by applying a more common mapping, for example: STEAK read as 'steek'; GAUGE as 'gawge'; WAND read to rhyme with 'hand'; and PINT to rhyme with 'mint'.

Test 5 - Reading of Non-words

Further evidence that DF is employing a phonological/alphabetic strategy for reading rather than having access to an orthographic strategy comes from his performance on Test 5. This test required reading of non-words derived from the irregular words in Test 4. There were two possible correct responses for each non-word; either they could be read by analogy to the irregular word from which they were derived or they could be pronounced in a regular manner. DF read 18/20 (90%) in a regular manner, for example FROSS was read to rhyme with the regular word CROSS, not with the irregular word GROSS. Both Frith (1985) and Seymour (1987) equate reading by analogy with utilisation of an orthographic reading strategy. It appears that this strategy is not available to DF.

Test 6 - Homophone Definition

This task assessed DF's strategies for accessing the meaning of words. He was required to define the word before pronouncing it. DF made significantly more errors when defining homophones, 22/32 (69%), than when defining non-homophones, 8/32 (25%), (Chi sq.=10.6, d.f.=1, $p<0.01$). Of the 25 homophones pronounced correctly, 15 (60%) were incorrectly defined as the wrong homophone, for example WRITE defined as 'not the left' and TIED as 'when the sea comes in'.

Many homophones are visually similar, for example DEAR and DEER. To determine whether his incorrect definitions of homophones were due to errors of visual perception and analysis, after pronouncing them, DF was asked to name the letters in the sequence in which they occurred in the word, while still looking at them (Coltheart et al., 1983). He did not name any of the letters incorrectly, even though he had mispronounced some of the words.

This excludes the possibility that his homophone confusion errors occurred by visual misperception. These 'homophone confusion' errors result from phonological reading and are characteristic of surface dyslexia (Coltheart et al., 1983). The phonological reader assembles the phonology of a word before accessing its semantic representation, and is therefore unable to disambiguate homophones, whose phonological representations are identical.

When items were incorrectly defined, their subsequent pronounciation corresponded with that definition, for example GUARD defined as 'back yard of a house' and pronounced as YARD; SOUL defined and pronounced as SOIL; and SWEAT as SWEET. As in the case of the homophones, the letters of these mis-read words were named correctly. Items for which no definition was given were mispronounced as non-words for example VEIN pronounced as VIN. Such errors further suggest that DF derives the meaning of words from their phonological representation, rather than directly from a visual representation.

Test 7 and 8 - Tests of Phonology

DF's percentage of correct responses on the Silent Tests of Phonology (Test 7) and on reading aloud of the words from the Silent Test (Test 8) are shown in Table 3.1.

Table 3.1
DF's performance on Tests 7 and 8.

	Regular words	Irregular words	Non-words
Silent Test:	n=20	n=20	n=20
% correct	85	75	80
Reading Aloud:	n=20	n=20	n=20
% correct	75	80	75
Response time:	n=20	n=20	n=20
(seconds)	82	100	172

There was no significant difference between silent and oral reading. This confirms that he did not have difficulty with the processes involved in the articulation of the words during reading. On the Silent Test DF's performance was best for Regular words and worst for Irregular words, as would be expected from previous test results. However, on the Reading Aloud Test his performance on the Regular words was worse than on Irregular words. This anomaly arose because DF was aware that his performance was being timed on the Reading Aloud test but not on the Silent Test. His shorter response time for Regular words was accompanied by decreased accuracy.

Test 9 - Spelling Test

In order to determine whether DF employed the same strategy for reading and spelling, Test 9 (shown in Appendix 7) was administered as a spelling to dictation task. DF's performance on this test is also shown in Appendix 7. His level of performance was poor, only 12/40 (30%) of the stimuli were spelt correctly. There was no significant difference between his performance on regular (7/20= 35% correct) and irregular words (5/20=25% correct) (Chi sq.= 0.118, d.f.=1, p= n.s.) although there was an advantage for regular words. Analysis of his errors suggests that he employed a phonological strategy for spelling, 89.3% of his errors were phonologically plausible such as CAMEL spelt as 'kamel', CLOCK as 'olok' and GUARD as 'gard'.

DF's poor performance on spelling the items in Test 9 contrasts with his relatively good performance on reading these items, as shown in Table 3.2. Such a discrepancy is characteristic of children who have failed to develop orthographic representions for spelling (Frith, 1985). DF's reliance on a phonological strategy

for spelling as well as for reading suggests that he does not have visual orthographic representations of words available either for spelling or reading.

Table 3.2

Comparison of DF's Reading and Spelling performance on Test 9
Percentage correct responses.

	Regular Words	Irregular Words
Reading:	100%	75%
Spelling:	35%	25%

Discussion of DF's assessment

DF was significantly better at reading Regular than Irregular words, a necessary and sufficient symptom for the diagnosis of Surface Dyslexia (Coltheart et al., 1983). Not only did DF display this symptom, he also displayed a number of others including: regularisation errors when reading irregular words; reading non-words derived from irregular words like regular words; and using a phonological code to access word meaning, resulting in 'homophone confusion errors'.

A comparison of DF's performance on the assessment tests with the performance of a Control group of 'normal' readers of similar Reading Age is shown in Appendix 17. DF's performance was not significantly different from that of the normal readers on Test 1, (Visual Lexical Decision Test), Test 2 (Auditory Lexical Decision Test) and Test 5 (Reading of Non-words). DF's reading of the Regular words (98% correct) in Test 4 (Reading of Regular and Irregular Words) was not significantly different from that of the Control Group (93.6%), ($Z = 0.907$, p=n.s.), but he was significantly

worse at reading the Irregular words (58% correct) than the Control Group (74.7%), ($Z = -2.256$, $p<0.05$). When the Low Frequency words were considered seperately, DF read all of the Regular words correctly (slightly better than the Control Group who had 90% correct), but on the Irregular words there was a large discrepancy between DF's performance (25% correct) and that of the Control Group (51.4%), ($Z = -1.98$, $p<0.025$). Thus, while DF's ability to read regular words did not deviate from that of normal readers of similar reading age, who were chronologically two years younger, his ability to read irregular words was dramatically reduced.

In terms of the Information Processing Model (See Appendix 1), regular words may be read correctly by either the lexical or phonological routes but irregular words may only be processed correctly by the lexical route. This requires that a visual representation be available in a Visual Input Lexicon. DF's poor ability to read irregular words may result either from impaired access to information in his Visual Input Lexicon or from failure to establish visual representations of irregular words in his Visual Input Lexicon. DF was able to read correctly 90% of the High Frequency Irregular words presented to him in Test 4. This implies that these familiar words were represented in his Lexicon and that he did not have have difficulty accessing his Visual Input Lexicon. However, he only read 25% of the Low Frequency Irregular words correctly, which suggests he has failed to establish representations for these low frequency words.

Considering the results of all of the assessment tests, there is strong evidence that DF relied on a phonological strategy for reading and spelling. Such strategy is appropriate for a younger child (Frith, 1985), and indicates that DF's development of literacy

skills has become arrested at the alphabetic stage. If DF was to improve his reading skills, he needed to progress to the 'orthographic', adult stage of reading, which required development, and utilisation of a visual orthographic reading strategy (Seymour, 1987). The goal of remediation of DF was to develop his visual reading strategy by extending his Visual Input Lexicon.

3.2.2 Case 2: SP

Test 1 - Lexical Decision - Visual Presentation

To determine SP's knowledge of English orthography Test 1 was administered. SP was significantly better at recognising real words (23/32=71.88% correct) than non-words (14/32=43.75% correct), (Chi sq.= 4.10, d.f.=1, $p<0.05$). His performance on non-words was not significantly better than chance (Chi sq.=0.788, d.f.=1, p=n.s.).

Test 2 - Lexical Decision - Auditory Presentation

On Test 2, SP was significantly better at making decisions about words (31/32=96,88% correct) than non-words (19/32=59.37% correct) (Chi sq.=11.06, d.f.=1, $p<0.001$). His overall performance on the Auditory version was significantly better than on the visual task (Chi sq.=4.4, d.f.=1, $p<0.05$). The discrepancy between auditory and visual performance suggests SP had a reading disability, however his relatively poor ability to recognise non-words (See Appendix 17), both auditorily and visually, may indicate an additional auditory processing difficulty, which may be an underlying cause of his reading difficulty.

Test 3 - Reading of Words and Non-words

SP's performance on this test was poor compared to normal readers of the equivalent Reading Age (see Appendix 17). He was significantly

better at reading words (21/32=65.63% correct) than non-words (8/32=25% correct) (Chi sq.=8.08, d.f.=1, p<0.01), which suggests that he employed a visual strategy for reading. This strategy relies on a visual representation of the word being present in the Visual Lexicon. Such representions for high frequency words should be established sooner than for low frequency ones, so reading of high frequency words should be better than for low frequency ones, regardless of orthogrphic regularity. This was the case for SP, whose reading of the high frequency words (15/16=93.75% correct) was significantly better than of the low frequency words (6/16=37.5% correct) (Chi sq.=8.67, d.f.=1, p<0.01).

SP's errors from Test 3 are shown in Table 3.3. He made a total of 35/64 (56.7%) errors, of which 28/35 (80%) were visual errors containing at least half of the letters of the target word. Of the 11 incorrect responses to real word targets 6 (54%) were substitutions of visually similar real word eg. CLINIC read as 'cling', PEDAL as 'plead' and PLEAT as 'plant'. The same percentage of non-word errors (13/24=54%) were lexicalisations eg. TRASS read as 'trace', KETTER as 'kettle' and SKRING as 'screen'. Such errors are logographic and indicate that the child has adopted an immature visual, logographic approach to reading (Seymour & Elder, 1986; Snowling, Stackhouse & Rack, 1986). These errors arise when only salient features of the word are attended to and a real word response with similar features is produced. The fact that SP made the same percentage of errors of the same type when reading words and non-words indicates that he used the same strategy for both types of stimuli.

Table 3.3

SP's reading errors from Assessment Test 3: Reading of Words and Non-words classified according to Stuart & Coltheart (1988)

Type of stimuli	Non-words n=32		Real words n=32		
Type of errors	Real word Responses	Non-word Responses	Real word Responses	Non-word Responses	Total
Number of errors	13	11	6	5	35
Errors	target/response	target/response	target/response	target/response	
letter/letter segments used			troupe/churp aisle/ears	mansion/absen	3
Beginning letter used	trass/trace savelty/softer ketter/kettle skring/screen present/greased broupe/borrow scarrow/square plinic/pint rasket/risked	oible/osold	pedal/plead clinic/cling present/persent		13
End letter used	juiz/quiz barden/pardon	houndry/youndry			3
Both end letters used	gleat/great foad/food	kire/kree frouble/furnble blint/bult garty/granty shild/shuged lansion/lanson tedal/' ndal surl/skurl rawn/rown	pleat/plant	casket/clausket novelty/novety foundry//foundary tusk/tosk	16

Further analysis of SP's errors (Table 3.3) indicated that, although he preferred a visual strategy for reading, he did attempt to utilise some rudimentary phonological knowledge when reading unfamiliar words. Of his total errors, 10/35 (45.7%) shared the same

beginning and end letters as the target while a further 13/35 (37%) shared the same initial letter. Stuart and Coltheart (1988) maintain that such errors indicate utilisation of some phonological knowledge, especially when non-word responses are produced. Errors such as RAWN read as 'rown', LANSION as 'lanson' and TUSK as 'tosk' could be classified as 'unsuccessful sound attempts' (Snowling et al., 1986) which indicate application of partial phonological knowledge.

SP's strategy for reading unfamiliar words whose visual forms were not recognised, was to look at the beginning of the word, apply simple grapheme to phoneme conversion rules and guess a real word he knows that has the same beginning (Table 3.3 shows that 12/13=92% of errors that shared the same beginning as the target were real words). This resulted in errors such as SKRING read as 'screen' and KETTEF as 'kettle'. If he could not guess a word he knew from the beginning sounds of the target, then he completed the letter to sound translation, but made errors especially with vowel sounds (Table 3.2 shows that 13/16=81% of responses that shared beginning and end letters with the target were non-words). These errors were the 'unsuccessful sound attempts' discussed above.

Test 4 - Reading of Regular and Irregular Words

SP's performance on Test 4 also indicated that he preferred a visual strategy for reading. His reading of regular words (25/40=62.5% correct) was not significantly different from irregular words (20/40=50% correct), (Chi sq.=0.813, d.f.=1, n.s.). The same number of high frequency regular and irregular words were read correctly (15/20=75%), confirming that his visual strategy was operating for high frequency words. His performance dropped to 10/20=50% for the

low frequency regular and 5/20=25% for the low frequency irregular words. Although this was not statistically significant (Chi sq.=1.706, d.f.=1, n.s.) there was an advantage for regular words, which would be expected if an inefficient phonological strategy was attempted for unfamiliar words. SP made only one error which could be classified as a regularisation (1/35=2.86% of total errors), he pronounced the 'T' in LISTEN. (SP's phonological abilities were investigated further, see below.)

Table 3.4

SP's Errors from Assessment Test 4: Reading of Regular and Irregular Words classified according to Snowling et al. (1986)

Type of stimuli	Regular words n=40	Irregular words n=40
Number of errors	15	20
Errors		
Visual/logographic	order/older base/bust rust/wrist modest/mustard broad/barrow peel/plead arch/ouch pest/pressed trout/sought	touch/torch group/ground machine/match debt/doubt hymn/human tomb/thumb ache/ouch pint/point steak/stalk grass/grass wand/weaned cough/caught shove/shovel (d)
Lexical-sounding	study/stable duel/dwarf	guage/greed beauty/pretty (s)
Unsuccessful sound attempts	simple/sliabort common/cumble manure/manore shrug/streag	subtle/stuttle orchid/orch wasp/wishp soared/serried
Alphabetic/ regularisation		liston/list-en

(d) could be classified as a Derivational error
(s) could be classified as a Semantic error

SP's errors when reading Regular and Irregular words are shown in Table 3.4. As in Test 3, most of his errors (28/35=83%) were visual (contained at least half of the letters of the target), and 28/35=74% were real words, so could be classified as logographic errors. He made one derivational error SHOVE read as 'shovel', and one semantic error BEAUTY read as 'pretty'.

SP frequently made derivational errors during assessment. He read: FRIGHT as 'frightened' ; BADGE as 'badger'; JEWEL as 'jewelry' and AMUSE as 'amused'. He also made a number of errors which could be classified as visual and derivational: eg. QUILT read as 'qualify'; SPADE as 'squared'; and SAFE as 'surfed'. To investigate his reading of suffixed words, SP was asked to read 31 suffixed words (eg. DUSTY and WORKER) and 31 pseudo-suffixed words (eg. IRONY and LIVER) (Funnell, 1987). Table 3.5 summarises the errors SP made on this test.

Table 3.5

Summary of SP's errors when reading Suffixed and Pseudosuffixed words.

Type of error	Examples of errors Target	Response	Number of errors
Visual	leader	ladder	16/35 = 46%
	lively	lovely	
	belly	bally	
Derivational:			10/35 = 28%
Suffix deleted	speaker	speak	
	treaty	treat	
	fairy	fair	
	corner	corn	
Suffix substituted	tally	taller	
Visual and Derivational	poetry	porter	9/35 = 26%
	proper	poor	
	stingy	singer	

His performance on the two types of words was not significantly different (Chi sq.=2.36, df.=1, n.s.). This indicates that there was no difference between his processing of suffixed and non-suffixed words, therefore his derivational errors were not due to differential processing of root and bound morphemes, but to his inefficient visual reading strategy. The high proportion of derivational errors agrees with reported results for phonological dyslexics (Funnell, 1983; Temple & Marshall, 1983). However, Funnell (1987) argued that these errors are visual errors resulting from the application of an immature visual reading strategy.

In addition to his derivational errors, SP produced one semantic paralexia on Test 4, and a further four during assessment (4% of his total errors on real word reading), but each was visually similar to the stimulus as well as semantically related. He read PENGUIN as 'pigeon' ; WINTER as 'weather' ; ACHE as 'ouch'; and PRICE as 'purse'. On different occasions, ARCH was also read as 'ouch' and PAUSE as 'purse'. Semantic errors have been reported for phonological dyslexics (Funnell, 1983; Snowling, Stackhouse & Rack, 1986). Seymour and Elder (1986) identified both derivational and semantic errors amongst the errors made by a group of normal beginning readers at the logographic stage of reading. The occurrence of such errors in SP's reading is consistent with his utilisation of an immature visual, logographic reading strategy, which is inappropriate for an 11 year old child.

Test 8 - Homophone Definition

SP's performance on Test 8 is shown in Appendix 17. SP's reading of homophones and non-homophones was equally accurate (22/32=69% correct). All of the 22 non-homophones read correctly were also

defined correctly, but only 18 of the 22 homophones read correctly were defined correctly. SP made two homophone confusion errors (10%). SP does not have difficulty disambiguating homophones because he used the visual representation of the word to access its meaning. However, SP did have difficulty naming the letters of the stimuli, and incorrectly named the letters of 12% of the 44 items which he had read correctly (See Table 3.6). Therefore SP's two homophone confusion errors could have arisen because of misreading and not because he used assembled phonology to access meaning. This agrees with his performance on other tests.

When presented with individual letters to name, SP did not make any errors, so it was unlikely that SP made letter naming errors because he did not know the correct letter names. His psychometric assessment did not find a deficiency in visual discrimination or perception, except in relation to reading, hence his letter naming errors were further evidence of his decoding strategy for printed words. His logographic reading strategy does not encourage attention to the details of letter sequences, particularly in the middle of words (Snowling et al., 1986). Although he is able to discriminate the words for reading and definition, he does not always attend to the details of their letters sufficiently in order to name them correctly in their correct sequence.

Table 3.6

SP's letter naming errors on Test 6

Target	Defined as:	Read as:	Spelled as:
claw	claw	claw	clow
pour	pour	pour	pore
where	where	where	whier
used	used	used	usud
moon	moon	moon	mon

Tests 7 and 8 - Tests of Phonology

SP's performance on the Silent Tests of Phonology (Test 7) and on reading aloud of the words from the silent test (Test 8) are shown in Table 3.7.

Table 3.7

SP's performance on Tests 7 and 8 : Percentage correct responses.

	Regular words	Irregular words	Non-words
Silent Test:	n=20	n=20	n=20
% correct	80	75	55
Reading Aloud:	n=20	n=20	n=20
% correct	65	80	25
Latency (seconds)	n=20	n=20	n=20
	58	51	99

SP showed no significant difference between silent and oral reading of words (Chi sq.=0.06, d.f.=1, n.s.). This indicates that he did not have difficulty with the articulation of the words. There was no significant difference between performance on Regular and Irregular words (Chi sq.=0.06, d.f.=1, n.s.) but, as expected from previous results, performance on non-words was significantly worse than on words (Chi sq.=10.39, df.=1, p=0.001) on the reading aloud test. Non-word performance on the Silent Test was at chance level (55% correct), indicating that he was guessing, and only 5/20 (25%) non-words were read aloud correctly.

Test 8 entailed reading aloud of three lists of stimuli: Regular words, Irregular words, and Non-words. The time taken for SP to respond to the 20 stimuli in each of these lists was measured (See Table 3.7). His response time increased from an average of 2.7 seconds per item on the word lists to 5.0 seconds per item on the non-word list. This slower response suggests a change from his

preferred visual reading strategy to a less efficient phonological one.

Test 9 - Spelling Test

In order to determine whether SP employed a similar strategy for reading and spelling, Test 9 (shown in Appendix 7) was administered as a spelling to dictation task. SP's performance on this test is also shown in Appendix 7. His level of performance was poor, only 12/40 (30%) of the stimuli were spelt correctly. There was no significant difference between his performance on regular (7/20= 35% correct) and irregular words (5/20=25% correct) (Chi sq.= 0.119, d.f.=1, p= n.s.) although regular words had a slight advantage.

Analysis of SP's errors indicated that 5/11 (18%) were visual errors indicating some word specific knowledge, as in PIECE spelt as 'pices', EIGHT as 'eigith' and SWORD as 'swrod'. Such dysphonetic errors are consistent with utilisation of imprecise, visual logographic representations for spelling, and suggest that orthographic representations had not been developed.

SP showed evidence of attempting to apply a phonological strategy for spelling. He produced 12/28 (43%) phonologically plausible errors of the type; COUSIN spelt as 'oussen', DREAM as 'drem' and ROAD as 'rode'. He also made 11/28 (40%) errors which could be classified as unsucessful sound attempts, for example; WRONG spelt as 'roing', ROAR as 'row' and RAYS as 'rass'. These types of errors indicate that SP does try to utilise a rudimentary phonological strategy for spelling, but this is not very sucessful.

SP performed better at reading the items from Test 9 than at spelling them, as shown in Table 3.8. This further suggests that he does not have orthographic representations available either for

reading or for spelling. He relies for both on imprecise visual logographic representtions and poorly developed phonological skills.

Table 3.8

Comparison of SP's Reading and Spelling performance on Test 9
Percentage correct responses.

	Regular Words	Irregular Words
Reading:	75%	65%
Spelling:	35%	25%

Disoussion of SP's assessment

SP was significantly better at reading familiar words than at reading unfamiliar words and non-words, a distinctive feature of phonological dyslexia (Funnell, 1983; Temple & Marshall, 1983). This difficulty with reading unfamiliar words caused SP to perform significantly worse than the Control Group on both the non-word reading (Test 5, $Z=-4.24$, $p<0.001$) and non-word Visual Lexical Decision (Test 1, $Z=-3.53$, $p<0.001$). It also accounted for his significantly poor performance on the Regular word reading in Test 4 ($Z=-3.696$, $p<0.001$). When his performance on High and Low Frequency Regular words was analysed seperately it was apparent that his difficulty was not with the High Frequency items ($Z=-1.5$, $p>0.05$, n.s.) but with the unfamiliar, Low Frequency items ($Z=-3.125$, $p<0.001$). The Control Group were able to employ their phonological strategy successfully for these stimuli while SP was not.

Although SP preferred to read by a visual logographic strategy, he had some phonic skills, as did other developmental phonological dyslexics (Snowling et al., 1986; Temple and Marshall, 1983).

Evidence for this comes from:

- a partial ability to read non-words (25% correct in Test 3 and Test 8)
- an advantage for reading Low Frequency Regular words (50% correct) over Irregular Low Frequency words (25% correct) observed in Test 4
- analysis of his errors on Test 3 (See Table 4) suggested that some phonological knowledge was used in reading, particularly when non-word responses were produced, for example: TAPER read as 'tapper'; TUSK read as 'tosk'; RAWN as 'rown'; LANSION as 'lanson'; and KEEM as'kneem'
- an increase in response latency when he knew he was required to read non-words (see Table 3.7).

Children may use different types of phonological knowledge when reading (Goswami & Bryant, 1990). SP's phonological strategy was investigated by analysing his errors from Tests 3 and 4 (Table 3.3 and Table 3.4). As discussed above SP relied on sequential decoding using grapheme-to-phoneme correspondences and then either guessing a word with similar beginning or completing the decoding and producing errors that were 'unsucessful sound attempts'.

It is widely reported that children with auditory processing difficulties may fail to develop appropriate phonological skills for reading (Funnell & Davison 1989; Goswami & Bryant, 1990; Snowling, 1987). SP had a history of ear infections, frequently found in children with defective auditory processing (Welman, 1989). His performance on the Auditory Lexical Decision task (Test 2 in Appendix 17) was significantly better than the Control Group for words ($Z=2.18$, $p<0.05$) as would be expected since he was chronologically 3 years older than the Control Group. However he was significantly worse at identifying non-words ($Z=-11.64$ $p<0.001$),

suggesting that he had an auditory input deficit. SP's performance on Test 7 (Silent Test of Phonology) and Test 8 (Reading Aloud Items from Test 7) did not indicate any difficulty with output phonology. An auditory input deficit would adversely affect his acquisition of grapheme-to-phoneme correspondences.

Phonological dyslexics read by recognising a visual representation of the word and using this to access the word's semantic and phonological representations (Temple & Marshall, 1983). Thus, like other phonological dyslexics, SP showed no effect of orthographic regularity or word length in reading. His difficulty with reading unfamiliar words and non-words whose visual forms were not recognised, resulted in lexicalisation errors in non-word reading and visual paralexias. He had difficulty distinguishing between words with similar visual configurations, so visual errors were common and, occasionally, derivational and visuo-semantic errors occurred. SP did not have difficulty disambiguating homophones since he accessed semantics directly from a visual representation of the word, but he did make errors when required to name the letters of words, which indicates a lack of attention to the detailed components of words. He lacks the analytic skills necessary for development of an alphabetic, phonological strategy for reading.

Considertion of SP's performance on the Assessment Tests provides evidence that he preferred an immature, visual logographic strategy for reading. He had not developed visual orthographic representations either for reading or spelling. Although he showed some evidence of developing a phonological strategy for both reading and spelling, this was quite rudimentary, inaccurate and not his strategy of choice. A phonological strategy is not only necessary

for reading unfamiliar words, but alphabetic skills are also a necessary foundation for the development of orthographic skills for both reading and spelling (Frith, 1985; Seymour, 1987; Snowling et al., 1986). In terms of the developmental models of literacy acquisition proposed by Frith and Seymour, SP's development was arrested at the early, logographic stage. In order to progress to the phonologocal stage of reading SP required extension of his knowledge and utilisation of grapheme-to-phoneme correspondence rules. This was the focus of his remediation.

3.2.3 General Discussion of Assessment

The subjects displayed very different patterns of performance on the Assessment Tests as a result of their different strategies for reading. DF's pattern of performance resembled that of a Surface Dyslexic, while that of SP corresponded to reports of Phonological Dyslexics (Seymour, 1987; Seymour & MacGregor, 1984). In terms of the developmental information processing model proposed by Seymour the reading development of both subjects was arrested prior to their development of orthographic reading. Surface or morphemic dysexics are prevented from establishing an orthographic lexicon by impaired wholistic visual processing. Phonological dyslexics fail to develop an adequate alphabetic or phonological lexicon which is a pre-requisite for orthographic development. The psycholinguistic assessment identified each subjects' reading strategies, stage of reading development and the focus of their remediation.

CHAPTER 4

4.0 REMEDIATION

The term 'Remediation' is employed to describe this section of the study, although the therapy programmes described below aimed to facilitate the acquisition of abilities that the subjects had not previously developed appropriately. For each subject the remediation was divided into three stages:

(i) Determination of the extent of the subjects' ability in the area which was the focus of remediation

(ii) Determination of items for training

(iii) Therapy programme

(iv) Determination of the efficacy of therapy

4.1 Case 1: DF

The aim of remediation of surface dyslexic subject DF was to develop his sight vocabulary and to encourage utilisation of a visual orthographic strategy for reading. To develop a visual reading strategy, it is not sufficient to establish visual representations of words in a Visual Input Lexicon, but it is also necessary to encourage direct access from this word specific information to the semantic representation of the word in the cognitive system. Thus remediation aimed both to establish visual representations of words and develop the use of a visual code to access word meanings.

4.1.1 Subject DF - Remediation Programme

(i) Determination of Irregular Words which DF could not read.

Irregular words (as defined below) do not obey the grapheme-to-

phoneme correspondence rules of English, and, therefore may only be read correctly by a visual strategy. To encourage DF to develop his visual strategy he was trained to read unfamiliar irregular words, whose meanings were known.

A set of 144 Irregular Words, which are shown in Appendix 12, of varying frequencies of occurrence were selected from Carroll, Davies and Richman (1971). Most of these words did not obey the most common grapheme-to-phoneme correspondence in English (Berndt, Reggia & Mitchum, 1987). For example, for the grapheme AI, Berndt et al. identify five possible corresponding phonemes, the most commonly occurring being 'ay' as in AID which has a conditional probability p=0.734, which means that in 73.4% of occurrences of AI in the corpus of words studied this grapheme was pronounced as 'ay'. The conditional probability that the grapheme AI will correspond with the phoneme 'uh-' as in VILLAIN is p=0.031. Thus, words such as VILLAIN, with conditional probabilities of p<0.35, were considered to obey uncommon grapheme-to-phoneme correspondences, and were classified as Irregular words. Also classified as Irregular were words such as SWORD, RHYME and LISTEN. These contain "word specific graphemic anomalies" (Berndt et al., p.5). In other words, they contain graphemes which occur in so few words that, although their conditional probability was high, their prior probability of occurrence was very low eg. SW in SWORD (p=0.00003); RH in RHYME (p=0.0001); and ST in LISTEN (p=0.0003).

Examples of both types of Irregular words were included in the list of 144 Irregular words which were administered to DF on three occasions, each one week apart. These were the baseline measures in the Pre-therapy period.

(ii) Determination of Items for Training

In the case of DF, the items for training were all Irregular words. They were derived from the 144 Irregular words by eliminating: words that DF could read correctly on more than one presentation out of three; words that DF could not define, ie. did not know the meanings of; and words which DF could spell correctly. The remaining 66 words were matched in pairs for frequency of occurrence (Carroll et al., 1971). Two matched sets of 33 words each were formed from these 66 words by random assignment of one word from each pair to either set. The 33 words in each set were randomly assigned to three groups of 11 items each. This formed the two matched sets of three Training Lists, shown in Appendix 18.

(iii) Therapy Programme

During the First Phase of Therapy one set of Training Lists (1, 2 and 3) were treated while the second set, Training Lists 4, 5 and 6 were not. In the Second Phase of Therapy the second set, Training Lists 4, 5 and 6 were treated but the first set was not. Each Phase of Therapy was divided into three periods during which one Training List was treated. At the end of the period DF's performance on both the treated list and the matched untreated list was assessed. Each period of treatment comprised four lessons. In each lesson three or four words from the appropriate Training List were introduced to DF. The following procedure, adapted from the 'Simultaneous Oral Spelling' method developed by Bradley (1981) and discussed in Bradley and Bryant (1985), was implemented for each word:

(i) The word was written in large sized, lower case print, by the therapist on a blank page of DF's exercise book.

(2) DF named the word and its meaning was discussed.

(3) DF wrote the word, in cursive script, himself. At the same time as he wrote each letter, he was required to say its alphabetic name aloud.

(4) He then named the word again, and checked what he had written by comparing it to the original written by the therapist.

(5) He read the word again, and steps 3 and 4 were repeated two more times.

(6) The words were covered and DF was required to write the word from memory, while naming the letters. He checked the word against the original, and if it was correct, moved to the next task, if it was not correct, this was repeated until the word was reproduced correctly.

(7) DF suggested a sentence illustrating the word meaning. This was discussed with the therapist, and dictated to DF who wrote it in his book.

(8) DF was requested to repeat steps 3,4,5 and 6 for each new word introduced in the lesson, on the afternoon of that lesson, as 'homework', and once a day on the days between lessons.

(9) In addition, each word was written in large, lower case letters on a small card. These were presented as 'flash cards' at the following lesson, and were also used as 'homework' to encourage whole word recognition. They were stored in an envelope at the back of DF's exercise book.

At the beginning of each lesson, the words trained in the previous lesson were tested by requiring DF to recognise, orally define and write them. Any word not known was retrained by repeating steps 3,4,5 and 6 and included with the new words introduced in the lesson.

(iv) Determination of the Efficacy of Therapy

At the end of each of the three periods of training which constituted a Phase of Therapy, DF was presented with the words from the Training List which had been treated during that period as well as the words of the matched Training List which had not been treated during that period. The words of both Training Lists were randomly arranged and printed on an A4 page in large, lower case letters. One item was presented at a time, the others were concealed. DF was required to read each item aloud. Responses were recorded by the therapist.

4.1.2 Subject DF - Results of Remediation

The performance of subject DF on the various treatment and control tasks was assessed at different stages of the remediation section of the study. Table 4.1 summarises the testing sessions and indicates which tasks were assessed in each. For each task the percentage of correct responses was scored.

Table 4.1
Summary of Data Collection

Stage of Study	Session Number	Task Administered
Pre-therapy	1	144 Irregular Words Homophone Definition T.R.O.G. Comprehension Arithmetic
	2	144 Irregular Words
	3	144 Irregular Words Homophone Definition T.R.O.G. Comprehension Arithmetic
First Phase of Therapy	Period 1 Period 2 Period 3	Training List 1 + Training List 4 Training List 2 + Training List 5 Training List 3 + Training List 6
Between Phases of Therapy	4	144 Irregular Words Homophone Definition T.R.O.G. Comprehension Arithmetic
Second Phase Therapy	Period 1 Period 2 Period 3	Training List 4 + Training List 1 Training List 5 + Training List 2 Training List 6 + Training List 3
Post-therapy	5	144 Irregular Words
	6	144 Irregular Words Homophone Definition T.R.O.G. Comprehension Arithmetic

(i) Results of Therapy

To determine the effect of therapy on the Training sets of Irregular words, DF's performance on the appropriate treated and untreated Training Lists was assessed at the end of each period of Therapy. The percentage of correct responses to each list is shown in Table 4.2.

Table 4.2
Subject DF - Results of Therapy

Percentage of correct responses to Training Lists after each period of training during the two Phases of Therapy

Period of Therapy	Session Number		
First Phase of Therapy	Period 1	Period 2	Period 3
Trained Lists*	100	100	90.9
Untrained Lists*	36.4	36.4	18.2
Second Phase of Therapy	Period 1	Period 2	Period 3
Trained Lists*	100	100	100
Untrained Lists*	90.9	81.8	100

* n=11 for each list

In the First Phase of Therapy, Training Lists 1, 2 and 3 were trained in Periods 1, 2 and 3 respectively, while Training Lists 4, 5 and 6 were untrained. In the Second Phase of Therapy, the previously untrained Lists 4, 5 and 6 were trained while Lists 1, 2 and 3 were not. There was a significant change in performance on the trained items. During the First Phase of Therapy DF's reading of trained words (Lists 1, 2 and 3) improved significantly relative to his reading of the matched, untrained words (Lists 4,5 and 6) ,(t-test for repeated measures: t=22, d.f.=2, p<0.005). In the Second Phase of Therapy performance on Lists 4, 5 and 6 improved significantly after training so, by the end of the Second Phase of Therapy, a t-test for repeated measures showed no significant difference between performance on the Training sets (t=1.42, d.f.=2, p=n.s.). The level of performance on Training Lists attained in the First Phase of Therapy was maintained over the Second Phase of Therapy.

The 66 words in the Training Lists were originally derived from the list of 144 Irregular Words shown in Appendix 16, and were

included in the 144 words which were administered to DF on six occasions before, during and after Therapy, as indicated in Table 4.1. Table 4.3 and Figure 4.1 show DF's performance on the 144 Irregular Words. In addition to his total performance, his separate performance on the treated and untreated items is shown.

Table 4.3
Subject DF - Results of Reading Irregular Words

Percentage of correct responses to the 144 Irregular Words on six trials

		Session Number*					
		1	2	3	4	5	6
Treated words: Training Lists 1, 2 and 3	n=33	9.1	9.1	3.0	87.9	97.0	100
Training Lists 4, 5 and 6	n=33	12.1	6.1	12.1	27.2	93.9	97.0
Un-treated words:	n=78	82.1	80.1	82.1	69.2	78.2	79.5
Total	n=144	49.3	47.2	47.2	63.9	86.1	88.2

* Sessions 1, 2 and 3 - in Pre-therapy Period
Session 4 - Between Phases of Treatment
Sessions 5 and 6 - in Post-therapy Period

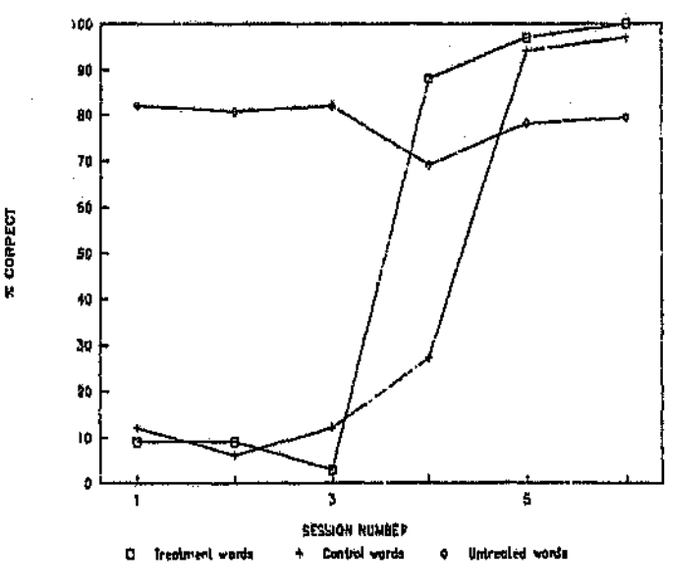

Figure 4.1. Subject DF - Irregular word reading.

There was a significant change in the percentage of total correct responses between the Pre-therapy and the Post-therapy period (Cochran Q= 153.3, d.f.=5, p<0.005). This change did not occur over the Pre-therapy period (Cochran Q= 0.788, d.f.=2, p= n.s.), nor was there any change over the Post-therapy period (McNemar Chi sq.=0.267, d.f.=1, p= n.s.). There was, however a significant improvement in the percentage of total correct responses over both periods of therapy (First Phase of Therapy, between Sessions Number 3 and 4; McNemar Chi sq.=8.45, d.f.=1, p= 0.002 : Second Phase of Therapy, between Sessions Number 4 and 5; McNemar Chi sq.=21.84, d.f.=1, p <0.001).

To determine whether this significant improvement in reading the 144 irregular words which occurred during the two Phases of Therapy was due to a generalised improvement in reading of all items, or was confined to a specific improvement in reading only the treated items, treated and untreated items were analysed separately The results of this analysis are shown in Table 4.4.

Table 4.4

Analysis of changes in DF's performance on treated and untreated items of the 144 Irregular Words.

	Session Number	Statistic		
Treated Items				
Overall	1 to 6	Cochran Q = 227.8	d.f.=5	p<0.005
Pre-therapy	1 to 3	Cochran Q = 0.875	d.f.=2	p= n.s.
Post-therapy	5 to 6	McNemar Chi sq.=0.25	d.f.=1	p= n.s.
Therapy	3 to 5	Cochran Q = 84.87	d.f.=2	p<0.005
Untreated Items				
Overall	1 to 6	Cochran Q = 9.686	d.f.=5	p= n.s.
Pre-therapy	1 to 3	Cochran Q = 0.118	d.f.=2	p= n.s.
Post-therapy	5 to 6	McNemar Chi sq.= 0	d.f.=1	p= n.s.
Therapy	3 to 5	Cochran Q = 5.58	d.f.=2	p= n.s.

Treated items (including items from all six Training Lists) showed a significant increase in performance over the six sessions (Cochran Q= 227.8, d.f.=5, p<0.005) but the untreated items did not (Cochran Q= 9.686, d.f.=5, p>0.05). Once again there was no significant change in performance on either treated or untreated items in the Pre-therapy or Post-therapy periods (See Table 4.4). There was a significant change in performance on the treated items over the therapy period, but not for the untreated items.

(ii) Results of Related and Unrelated Processing Tasks

The Related Processing task for DF was the Homophone Definition task shown as Test 6 of the Assessment tasks. This task was included in the study to allow for determination of the generalisation of the effects of therapy. The Unrelated Processing tasks were the Test of Receptive Grammar (T.R.O.G.), and the H.S.R.C. Comprehension and Arithmetic tests. These were included in the study to allow the potentially confounding effects of spontaneous improvement, involvement in treatment and repeated testing to be separated from the effects of therapy.

Table 4.5 shows the percentage of correct responses made by DF on the related and unrelated processing tasks at the different stages before, during and after therapy, as shown in Table 4.1. There was no significant change in performance on the Homophone Definition task (Chi sq.=0.226, d.f.=3, p=n.s.), the T.R.O.G. (Cochran Q=0.6, d.f.=3, p=n.s.) or Comprehension task (Chi sq.=0.447, d.f.=3, p=n.s.) over the period of the study. There was a significant increase in performance on the Arithmetic Test (Cochran Q=11.6, d.f.=3, p<0.01). This increase in performance began in the Pre-therapy period and continued through the Post-

therapy period. None of the other tasks monitored showed an increase in performance during these periods.

Table 4.5
Subject DF - Performance on Related and Unrelated Processing Tasks
Percentage of correct responses to the tasks on four trials.

Task		Session Number[a]			
		1	2	4	6
Related - Homophone Definition[b]	n=32	53	50	50	57.4
Unrelated - T.R.O.G.	n=80	92.5	93.8	93.8	91.3
Comprehension[c]	n=30	43	40	43	53
Arithmetic	n=20	20	35	45	55

[a] Sessions 1 and 2 - in Pre-therapy Period
Session 4 - Between Phases of Treatment
Session 6 - At the end of Post-therapy period

[c] Form A administered in First and Fourth Sessions
Form B administered in Second and Sixth Sessions

[b] % of homophones read correctly and spelt correctly but not defined correctly, i.e. Confusion Errors.

4.1.3 Subject DF - Discussion of Results

The aim of DF's remediation was to develop his visual reading strategy and utilisation of a visual code for access to semantic information. The remedial therapy focused on treatment of low frequency irregular words which DF could not read or spell correctly but could define. DF's performance on the trained irregular words improved as a result of therapy. This was indicated by superior performance on the trained items in Training Lists 1,2 and 3 over the matched, untrained items during the First Phase of Therapy, as shown in Table 4.2. During the Second Phase of Therapy performance on the words in Training Lists 4, 5 and 6 improved once they had

been treated. Performance on the items treated in the First Phase did not deteriorate over the Second Phase and, Table 4.3 shows, the level of performance on all treated items was maintained in the Post-therapy period, indicating the permanence of the effects of therapy on treated items. Irregular word reading did not continue to improve over the Post-therapy period, after treatment had terminated, which corroborates the specificity of the effects of therapy.

DF did not show any increase in ability to read the list of 144 irregular words during the three Pre-therapy trials, as can be seen from Table 4.3. This denotes the absence of effects of spontaneous improvement, being in therapy or of pre-test sensitisation for this task. If any of these had been operating they would have caused improved performance in this Pre-therapy period, when treatment was absent. Improvement in performance only occurred after treatment and remained stable over the two Post-therapy trials, which confirms the efficacy of therapy on treated items.

Further evidence that the effect of therapy on the treated items was not due to generalised effects such as spontaneous improvement, being in therapy or repeated testing comes from the stable performance on the unrelated processing tasks, the T.R.O.G. and the Comprehension, as shown in Table 4.5. Had such influences been operating they would have led to a simultaneous improvement in performance on these tasks as well as on irregular word reading. There was, however, a significant and continuous improvement in DF's Arithmetic results throughout the study. This improvem. was consistent and did not coincide with any of the stages of the remediation study, implying that it was the result of a specific improvement in arithmetic abilities and not related to DF's language

processing abilities or the remediation.

Therapy for DF caused a quantitative change in perfo-mance on treated irregular words but the effects were specific and did not generalise to untreated items. In order to determine whether there was a change in processing strategy the study assessed performance on a related processing task, that of Homophone definition. In view of the lack of generalisation of the effects of therapy to the untreated irregular words, it was not surprising that there was no change in performance on the homophone task, as none of the stimulus items of that task were incorporated into the treatment lists. The percentage of homophone confusion errors did not change over the period of the study which implies there was no alteration of DF's strategy of employing a phonological code to access semantic information. This implies that there was no qualitative change in DF's reading strategies.

A more sensitive test, than defining Homophones, of DF's ability to generalise from the words he was trained to read would have been one that required him to read words containing the same irregular segments as those in the treated words. For example, if the word ROUGH was trained, the words TOUGH and ROUGHEST could be tested to determine whether the irregular segment could be abstracted from the trained item and generalised to a different context. Such generalisation would have indicated more clearly that therapy established sub-word elements in an orthographic lexicon.

If therapy only produced a quantitative change in strategy but no qualitative change, it is necessary to account for DF's ability to read the irregular, low frequency, treated items without visual orthographic processing. In assessment DF was able to read high frequency irregular words, which was assumed to indicate that he had

the ability to establish visual orthographic representations of words with which he had become familiar. This assumption seemed to be confirmed by the effectiveness of treatment that focused on establishing visual representations of treated irregular words. However, it is possible that this assumption was incorrect and DF never employed a visual orthographic strategy, even for reading of familiar high frequency irregular stimuli.

In terms of Seymour's 'dual foundation' model (Seymour, 1987, 1990b), development of the orthographic lexicon requires prior establishment of a logographic and an alphabetic lexicon, both of which coexist with the developing orthographic lexicon. It is possible that the treated items (and highly familiar irregular words) constituted a 'response set', similar to the initial 'reading vocabulary' of beginning readers (Seymour & Elder, 1986), which became established in his logographic lexicon. Serial processing of the sequences of letters of the treated words was encouraged during remediation. Thus the letters and letter sequences could have operated as 'salient features' to guide the selection of responses from the 'response set' of treated items. In other words, DF could have continued to apply an established combination of alphabetic and logographic processing strategies to the treated items. This explanation is supported by examination of the error responses to the treatment and control items during the two phases of therapy. DF occasionally confused visually similar items from the 'response set'. The word 'trough' which had been treated was confused with visually similar words, ROUGH and THROUGH in the control lists which had not, at that stage been treated. At the end of therapy, when all items had been treated, TROUGH was read as 'through' and RECEIPT as 'recipe'.

In summary, DF's results established that the remediation technique was highly specific and only achieved improvement of his ability to read trained irregular words. It appears that this improvement was a consequence of quantitative modification of his existing reading strategy although the results cannot exclude the possibility of qualitative change. The theoretical implications of DF's results are discussed in Chapter 5.

4.2 Case 2: SP

Remediation of Phonological Dyslexic SP aimed to extend his knowledge and use of grapheme-to-phoneme correspondences in reading.

4.2.1 Subject SP - Remediation Programme

(i) Determination of SP's knowledge of Grapheme-to-Phoneme Correspondences

The extent of SP's knowledge of grapheme-to-phoneme correspondences was investigated, beginning with single sound/let correspondences and progressing to more complex ones. SP was presented with a randomised list of all the letters of the alphabet. He was able to sound and name the individual letters correctly. To further investigate his knowledge of common grapheme-to-phoneme correspondences, SP was asked to read regular, low frequency words to read.

The First List of Regular Words presented to SP consisted of 68 words with a frequency of occurrence between 0 and 50 per million in the Carroll et al. (1971) corpus, as shown in Appendix 18. Low frequency words were unlikely to be represented in his visual input lexicon, and probably require a phonological strategy to be decoded successfully. Each word contained target grapheme-to-phoneme correspondences which were the most commonly occurring, ie. had a prior probability of occurrence p>0.001 (Berndt et al., 1987). Thus, words such as FROCK were included (the grapheme has a prior probability, p=0.0026), while words such as WRAP with p=0.0004 were not.

When there was more than one possible mapping for the grapheme onto a phoneme, the most commonly occurring mapping was included,

and only words with grapheme-to-phoneme correspondences that had a conditional probability, p>0.5 (Berndt et al., 1987) were included. Thus, the list of regular words included items such as CRUNCH in which the target grapheme, CH, corresponds to the phoneme 'tch', its most common mapping with a high conditional probability of p=0.840, but did not include items such as CHEF in which the target grapheme, CH, maps onto the phoneme 'sh' with a low conditional probability, p=0.069.

This list of 89 words were randomly arranged and written in large print on A4 paper. They were presented one word at a time for SP to read aloud. A different randomised arrangement of the list was presented to SP on three occasions, each one week apart. These were the three baseline measures on regular words in the Pre-therapy period.

(ii) Determination of the Items for Training

SP's performance on the First List of Regular Words was examined. He was significantly better at reading words with frequency of occurrence above 10 per million (51.5%) than those below 10 per million (29%) (Chi sq.=13.9, df=1, p<0.001). Some of the words with frequencies above 10 per million may be represented in his visual lexicon, and were read by a visual strategy. During his assessment, reported in section 3.2.2, SP read approximately 25% of non-words correctly. If unfamiliar words are perceived as non-words by SP, then he should be able to read approximately 25% of them. He read 29% of the words with a frequency of occurrence below 10 per million correctly, so it appeared that he was unfamiliar with most of them, treated them like non-words, and attempted to read them by his inefficient phonological strategy. Thus, it was considered that

these low frequency words were appropriate for testing SP's phonological strategy, in particular, his knowledge of grapheme-to-phoneme correspondences.

Based on SP's performance on the First List of 89 Regular Words a Second List of Regular Words was devised containing 97 words with frequencies below 10 per million (Carroll et al., 1971). This Second List of Regular Words is shown in Appendix 20. This list was more balanced than the First List to allow more accurate comparison of SP's performance on each of the selected grapheme-to-phoneme correspondences. The 97 words were selected so as to include five examples of each of the most commonly occurring grapheme-to-phoneme mappings of the most frequently occurring vowel and consonant digraphs (Berndt et al., 1987). The most common grapheme-to-phoneme mappings had conditional probabilities greater than 0.5. The most commonly occurring vowel and consonant digraphs eg. OA, AU, OI and CH, CK, LE, had a prior probability greater than 0.001. The 97 words also included five examples of the most common, context sensitive rules such as the modification of the pre-consonant vowel by a final position E. Appendix 21 shows an analysis of the target grapheme-to-phoneme correspondences in the Second List of Regular Words. (Some words contained more than one target correspondence, thus 97 words were sufficient to provide five examples of each of the 20 correspondences.)

Stimuli of the Second List of Regular words were randomly ordered and presented to SP following the same procedure as for the First List. This list was only presented on one occasion, since its purpose was to establish which grapheme-to-phoneme correspondences should be included for treatment. Appendix 22 shows a summary of SP's performance on the Second List of Regular Words. The grapheme-

to-phoneme correspondences where SP read four or five out of the five examples correctly were: OW in BARROW; QU in QUILT; NG in HANGER; LE in BEETLE; EE in DEED; CK in SNACK; CH in MUNCH. These correspondences were not used for remediation. The most commonly occurring of the remaining 12 grapheme-to-phoneme correspondences which SP found difficult were selected for treatment. As shown in Appendix 22, these were:

A_E corresponding to 'ay' as in ATE
O_E corresponding to 'o' as in CODE
I_E corresponding to 'ai' as in ICE
U_E corresponding to 'yu' as in USE
OO corresponding to 'oo' as in BOOT
EA corresponding to 'ee' as in EAT

The correspondences to be remediated were matched for visual similarity and frequency of occurrence (determined by comparing the product of the prior and conditional probabilities). The correspondence A_E was matched with O_E, I_E with U_E and OO with EA. One from each matched pair was randomly assigned to two training sets. The First Training Set contained correspondences A_E, I_E, and OO. The correspondences O_E, U_E and EA were assigned to the matched Second Training Set.

(iii) Therapy Programme

During the First Phase of Therapy the correspondences in the First Training Set, were treated, while those in the Second Training Set were untreated. In the Second Phase of Therapy, the correspondences of the Second Training Set were treated while those of the First Set were not. Each Phase of Therapy was divided into three periods and one correspondence was treated in each period. At the end of each

period SP's performance on words containing both the trained and the matched, untrained correspondence was assessed. Each period of training comprised four lessons. In each lesson approximately five words were introduced which obeyed the correspondence to be treated. Words used in treatment were suggested by the subject, with the constraint that they obey the grapheme-to-phoneme correspondence selected for treatment at each particular stage. Lower case plastic letters were used to visualise the words, as in the first of Bradley's teaching methods, for improving phonological skills (Bradley & Bryant, 1985; p.137). The following procedure was implemented in each lesson.

(1) SP suggested words and formed the words with the plastic letters.

(2) SP was encouraged to see the commonalities in the words by; sounding the words aloud, and relating the phonemes to the graphemes of the words, and by moving the plastic letters to show that the target grapheme was related to the same phoneme, even in different words.

(3) He then copied the words into his exercise book, saying the name of each letter as he wrote it.

(4) He checked his spelling against the plastic letters by naming each letter, then sounded the word and read it. He repeated this three times for each word.

(5) SP was instructed to repeat this procedure for each word, at home on the afternoon of the lesson, and once on the day between lessons.

(6) At the end of each lesson SP combined the words into a mnemonic sentence (Goulandris, 1985), for example: The FOOL sat by the COOL POOL when he should have been at SCHOOL. He wrote this

sentence under the words in his exercise book, and used it to remind himself of the correct way to pronounce the words.

(7) At the beginning of each lesson, the items treated in the previous lesson were revised before new items were introduced.

(iv) Determination of the Efficacy of Therapy

A Training Test was devised for each of the matched pairs of correspondences. Appendix 23 shows these three Training Tests. Each Test contained 20 low frequency words, 10 examples of each of the Training Correspondences, which SP had not generated during treatment. Thus, Training Test 1 comprised A_E and O_E words. It was administered on two occasions; at the end of the first period of training in the First Phase of Therapy, following treatment of the A_E correspondence, and at the end of the first period of the Second Phase of Therapy, following treatment of the correspondence O_E. Similarly, Training Tests 2 and 3 were administered at the end of the second and third periods of treatment in both the First and Second Phase of Therapy. The stimuli of the each Training Test were randomly arranged and printed in large, lower case letters on A4 paper. They were presented one item at a time, the others were concealed. SP was instructed to read the items aloud. His responses were recorded by the therapist.

4.2.2 Subject SP - Results of Remediation

The performance of the subject SP on the various tasks was assessed at different stages of the study. Table 4.6 summarises the sessions and indicates which tasks were assessed in each. For each task the percentage of correct responses was scored.

Table 4.6
Summary of Data Collection

Stage	Session Number	Task Administered
Pre-therapy	1	89 Regular Words Non-word Reading T.R.O.G. Comprehension Arithmetic
	2	89 Regular Words
	3	89 Regular Words Non-word Reading T.R.O.G. Comprehension Arithmetic
First Phase of Therapy	Period 1	Training Test 1
	Period 2	Training Test 2
	Period 3	Training Test 3
Between Phases of Therapy	4	89 Regular Words Non-word Reading T.R.O.G. Comprehension Arithmetic
Second Phase of Therapy	Period 1	Training Test 1
	Period 2	Training Test 2
	Period 3	Training Test 3
Post-therapy	5	89 Regular Words
	6	89 Regular Words Non-word Reading T.R.O.G. Comprehension Arithmetic

(i) Results of Therapy

The effect of therapy on treated and untreated grapheme-to-phoneme correspondences was assessed during the Therapy period by administration of the appropriate Training Test at the end of each period of training, as shown in Table 4.6. Table 4.7 and Figure 3 show SP's percentage of correct responses on these tests.

Table 4.7
Subject SP - Results of Therapy

Percentage of correct responses to the trained and untrained items in the Training Tests after each period of training during the two Phases of Therapy

Phase of Therapy			
First Phase of Therapy	Period 1	Period 2	Period 3
Trained items*	100	100	90.9
Untrained items*	50	40	50
Second Phase of Therapy	Period 1	Period 2	Period 3
Trained items*	100	90	100
Untrained items*	100	90	90

* n=10 for each list

The results of the therapy show a significant improvement in performance on the words containing the correspondences which had been trained. In the First Phase of Therapy SP's reading of the trained items in the Training Tests was significantly better than his performance on the matched, untrained items in the Training Tests (t-test for repeated measures: t=16, d.f.=2, $p<0.005$). In the Second Phase of Therapy, during which the previously untrained correspondences were treated, a t-test for repeated measures showed no significant difference between performance on these and the items trained in the First Phase (t=1, d.f.=2, p=n.s.). The level of performance on the trained items attained in the First Phase of Therapy was maintained over the Second Phase of Therapy.

To determine the effects of the remediation programme on SP's reading, his performance on the list of 89 Regular Words shown in Appendix 19, was assessed on the six occasions, as indicated in Table 4.6, before, during and after therapy. Some of the words of this list contained the grapheme-to-phoneme correspondences which were the targets of remediation. These items were considered as

'treated' while those which did not contain treated correspondences were the 'untreated' items. Table 4.8 and Figure 4.2 show SP's performance on the 88 Regular Words.

Table 4.8
Subject SP - Performance on Reading Regular Words

Percentage of correct responses to the First List of 89 Regular Words on six trials

		Session Number*					
		1	2	3	4	5	6
Words containing treated correspondences	n=29	27.6	27.6	27.6	55.2	82.8	82.8
Words containing untreated correspondences	n=60	45.0	36.7	43.3	55.0	63.3	61.7
Total	n=89	39.0	33.7	38.2	55.1	69.7	68.5

*Sessions 1, 2 and 3 - in Pre-therapy Period
Session 4 - Between Phases of Treatment
Sessions 5 and 6 - in Post-therapy Period

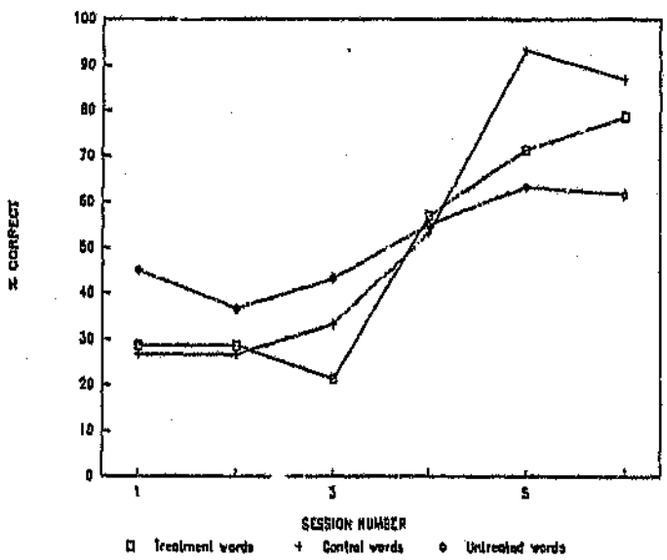

Figure 4.2. Subject SP - Regular word reading.

There was a significant improvement in the percentage of correct responses for the total 89 words over the six trials (Cochran Q= 61.91, d.f.=5, p<0.005). However, there was no significant change in the percentage of correct responses either over the Pre-therapy or the Post-therapy periods (Pre-therapy: Cochran Q= 4.6, d.f.= 2, p= n.s.; Post-therapy: McNemar Chi sq.=0, d.f.=1, p= n.s.) so this improvement did not occur over these periods. The improvement in performance was confined to the First and Second Phases of Therapy when there were significant changes (First Phase: McNemar Chi sq.=4.97, d.f.=1, p= 0.02; Second Phase: McNemar Chi sq.= 5.76, d.f.=1, p= 0.016).

To determine whether this significant improvement, during the First and Second Phases of Therapy, in reading the 89 regular words was due to a generalised improvement in reading of all items, or was confined to a specific improvement in reading only the words containing treated correspondences, treated and untreated items were analysed separately. The results of this analysis are shown in Table 4.9.

Table 4.9
Analysis of changes in SP's performance on words containing treated and untreated correspondences in the 89 Regular Words.

	Session Number	Statistic		
Treated Items				
Overall	1 to 6	Cochran Q = 46.97	d.f.=5	p<0.005
Pre-therapy	1 to 3	Cochran Q < 0	d.f.=2	p= n.s.
Post-therapy	5 to 6	McNemar Chi sq.=0	d.f.=1	p= n.s.
Therapy	3 to 5	Cochran Q = 16.65	d.f.=2	p<0.005
Untreated Items				
Overall	1 to 6	Cochran Q = 23.59	d.f.=5	p<0.005
Pre-therapy	1 to 3	Cochran Q = 2.27	d.f.=2	p= n.s.
Post-therapy	5 to 6	McNemar Chi sq.=0.68	d.f.=1	p= n.s.
Therapy	3 to 5	Cochran Q = 7	d.f.=2	p<0.05

There was a significant change in performance on both the treated and untreated correspondences over the six trials (see Table 4.6). Performance on neither treated nor untreated items changed significantly in the Pre-therapy or Post-therapy periods, thus the change in performance was confined to the Therapy period. The improvement in performance for treated items (27.6% to 82.8%) was greater than that for the untreated items (43.3% to 63.3%).

(ii) Results of Related and Unrelated Processing Tasks

The Related Processing Task for SP was the Non-word reading test shown as Test 5 of the Assessment tasks. This task was included in the study to allow for determination of the extent of generalisation of treatment. The Unrelated Processing tasks were the T.E.C.G. and the H.S.R.C. Comprehension and Arithmetic tests. These tasks were included in the study as control measures. Table 4.10 shows the percentage of correct responses made by SP on the related and unrelated processing tasks at different stages of the study. As indicated in Table 4.6, these were before, during and after therapy.

SP's performance on the related language processing task, the Non-word Reading showed a significant change over the period of the study (Cochran Q= 10.87, d.f.=3, $p<0.025$). There was a significant improvement in performance between Sessions 4 and 6 (McNemar Chi sq.=5.06, d.f.=1, $p=0.024$). There was no change in performance in the Pre-therapy period (McNemar Chi sq.=0.8, d.f.=1, p=n.s.) nor over the First Phase of Therapy (McNemar Chi sq.=0.75, d.f.=1, p=n.s.).

Table 4.10
Subject SP - Performance on Related and Unrelated Processing Tasks

Percentage of correct responses to the tasks on four occasions

Task		Session Number*			
		1	2	4	6
Related - Non-word Reading	n=32	25	37.5	25	56.3
Unrelated - T.R.O.G.	n=80	92.5	92.5	93.8	93.8
Comprehension¹	n=30	50	63	57	66
Arithmetic	n=20	50	40	45	35

* Sessions 1 and 2 - in Pre-therapy Period
Session 4 - Between Phases of Treatment
Session 6 - At the end of Post-therapy period

¹ Form A administered in First and Fourth Sessions
Form B administered in Second and Sixth Sessions

To determine whether the strategy SP used to read non-words altered during the same period his errors were analysed. Appendix 24 shows SP's responses to the non-word stimuli on the four sessions. Errors in which a non-word is read as a visually similar real word indicate utilisation of a visual reading strategy for reading. The percentage of non-words which SP read as real words was similar for Sessions 1 (40.6%), 2 (37.5%) and 4 (43.8%) but reduced to 25% at Session 6. Although the amount of the reduction failed to reach a statistically significant level (Chi sq.=1.73, d.f.=1, p=0.18), it occurred between Sessions 4 and 6, and coincided with both the Second Phase of Therapy and a significant improvement in non-word reading.

There was no significant change in SP's performance on the unrelated processing tasks over the period of the study: T.R.O.G. (Cochran Q=0.222, d.f.=3, p=n.s.); Comprehension (Chi sq.=0.528,

d.f.=3, p=n.s.); and Arithmetic (Cochran Q=1 81, d.f.=3, p=n.s.).

4.2.3 Subject SP - Discussion of Results

The assessment of subject SP determined that he preferred a visual logographic strategy for reading. His reading was characterised by superior performance on familiar words over unfamiliar words and non-words, with a tendency to produce visual and lexicalisation errors. This pattern of performance resembled that of subjects with acquired and developmental 'phonological dyslexia' (Seymour, 1986; Snowling et al., 1986; Temple & Marshall, 1983), as well as younger, normal readers (Frith, 1985; Seymour & Elder, 1986). In order to progress to the phonological stage of reading (Frith, 1985) SP required development of phonological abilities. The aim of remediation for SP was to develop his knowledge and use of grapheme-to-phoneme correspondences. The remedial therapy focused on treatment of commonly occurring grapheme-to-phoneme correspondences which SP did not know.

The results of SP's remediation were similar to those for DF. There was a significant, stable effect of therapy on words containing the treated correspondences (Tables 4.7 and 4.8). This effect could not be ascribed to general effects such as spontaneous improvement, effects of being in therapy or repeated testing, since there were no significant changes in performance either during the study (on any of the Unrelated processing tasks) or during the Pre-therapy and Post-therapy periods (on any of the tasks monitored).

In contrast to DF, however, SP's results indicated that the effects of therapy were not confined to the treated items but did generalise to the regular words containing untreated correspondences as well as the non-words of the Related Processing task, as shown in

Tables 4.8, 4.9 and 4.10. His performance on the untreated items in the list of 88 Regular words improved significantly from 43.3% to 63.3% over the Therapy period (Cochran Q =7, d.f.=2, p<0.05). This improvement was absent in the Pre-therapy period and did not continue in the Post-therapy period indicating that it was a direct effect of therapy.

Performance on the Non-word reading task remained stable over the First Phase of Therapy but increased significantly over the Second Phase (McNemar Chi sq.= 5.06, d.f.=1, p=0.024). These results imply that treatment had an effect on the underlying processing strategy applied during word and non-word reading. This hypothesis is supported by a reduction in the percentage of lexicalisation errors (from 43.6 to 25) on the Non-word reading task at the end of the Post-therapy period, as shown in Appendix 24. The reduction in these errors denotes a change from a logographic strategy towards a phonological strategy with a consequent increase in the number of non-words which were read as non-words. As suggested for DF, a more accurate indication of a change in processing strategy would have been to measure response latency. If the increase in performance on the Non-word reading task and the reduction in lexicalisation errors had been accompanied by a lengthening in the response latencies related to the length of the stimulus, this would have confirmed a strategy change. Seymour (1990a) incorporated a measure of response time in his study of remediation of phonological dyslexic subject DK, and he established that there was a change from a holistic logographic strategy for reading to a slower alphabetic strategy following intervention.

According to Seymour's 'dual foundation' model of reading acquisition, development of the orthographic lexicon depends on

establishing both a core 'logographic lexicon' and an 'alphabetic lexicon' which, in turn, depends for its development on the acquisition of phonological awareness. SP's reading development was arrested at the logographic stage, attesting to his failure to establish and utilise an alphabetic lexicon. According to Seymour's model a failure to develop phonological awareness may underlie this lack of development of an alphabetic lexicon.

Remediation aimed to extend SP's knowledge of grapheme-to-phoneme correspondences. The remediation strategy was based on that utilised by Bradley and Bryant (1985). This teaching strategy is thought to encourage phonological awareness in addition to teaching grapheme-to-phoneme correspondences (Goswami & Bryant, 1990). The generalisation of the effects of SP's therapy to the untreated items and the non-word reading task, suggests that therapy was effective not only in establishing previously unknown grapheme-to-phoneme correspondences, but also in development of phonological awareness. This phonological awareness prompted utilisation of both the newly acquired correspondences and those correspondences which SP had managed to acquire prior to intervention.

Although SP's phonological awareness was not assessed directly during the study, his assessment did suggest that he may have impaired auditory processing which might imply impaired development of phonological awareness. The remediation employed visual and auditory representations of words. By manipulation of plastic letters, segmentation of these representations was encouraged to establish letter-sound correspondences, as well as generalisation of sound and letter segments from one word to another. It seems feasible, therefore, to postulate that SP had failed to spontaneously develop phonological awareness in the auditory

modality, but when this was explicitly combined with instruction in the visual modality, phonological awareness was enabled. A number of types of phonological awareness have been suggested (Goswami & Bryant, 1990; Morais, Alegria & Content, 1987), some of which are usually established before the child begins to read, including awareness of rhyme and alliteration and others which develop as a consequence of familiarity with alphabetic script. To elucidate the interaction between developing phonological awareness and alphabetic processing it is recommended that future studies of remediation of developmental phonological dyslexics should include assessment and monitoring of phonological awareness.

To summarise, SP's results established that the remediation programme was effective not only in producing a quantitative improvement in reading ability, but also a qualitative change in reading strategy. The theoretical implications of SP's results are discussed in Chapter 5.

CHAPTER 5

5.0 CONCLUSIONS AND IMPLICATIONS

In the past twenty years, a substantial literature concerning modular information processing models of skilled reading has been established. Based on these, models of the development of reading and spelling skills have been proposed. In the light of these models explanations for different types of acquired and developmental dyslexia have been advanced, and procedures for the assessment of reading skills have been developed. However, there has been a paucity of model-based studies of remediation, either of acquired or developmental disorders. The present study sought to address this area by applying a model-based approach to the assessment and remediation of two developmental dyslexics.

Two subjects with significant reading problems were selected. Each subject exemplified one of the two major patterns of breakdown of the acquisition of reading skills. Assessment of one subject, DF, indicated that he preferred a phonological strategy for reading, while the other subject, SP, relied on a visual logographic strategy. DF's pattern of performance on the assessment tests was characteristic of developmental surface or morphemic dyslexics (Coltheart et al., 1983; Seymour 1986, 1990a). SP's performance was characteristic of developmental phonological dyslexics (Seymour, 1986; Snowling, 1986; Temple & Marshall, 1983). The reading strategies of both subjects were appropriate for chronologically younger children, supporting Frith's (1985) notion that dyslexia is due to a failure to progress to the next stage of skill acquisition. In order to progress to the orthographic stage of skilled reading

appropriate for their ages, both subjects required establishment of a visual orthographic lexicon (Frith, 1985; Seymour, 1990b).

Although the psycholinguistic assessment identified which processing strategies had been acquired and the developmental model of reading identified the stage of reading skill acquisition, neither could prescribe the exact content of a remediation programme. Two approaches are possible, either training the strategy which the subject has not acquired thus allowing development to proceed, or to directly attempt to establish an orthographic lexicon, even though prior skills have not been mastered. Frith and Seymour have proposed models of reading acquisition which emphasise that both logographic and alphabetic skills are necessary prerequisites for orthographic development. This suggests that remediation should focus on development of these prerequisite skills in order to overcome the blockage to development. The present study adopted this approach, so remediation of the surface dyslexic subject aimed to develop his visual reading strategy, while for the phonological dyslexic the goal was development of a phonological strategy.

In the remediation stage of the study different therapy programmes were devised and administered to each of the subjects. Their efficacy was investigated employing a single subject, longitudinal design which allowed effects of therapy to be isolated from the potentially confounding effects of spontaneous improvement, being involved in therapy and repeated testing. In addition to isolating the effects of therapy, the design allowed determination of the extent of generalisation of these effects to the underlying reading strategy. The remediation programmes administered to the two cases of developmental dyslexia were

effective in causing improved performance on the treated items for both subjects. In the case of the phonological dyslexic therapy effected a change in reading strategy but this was not apparent for the surface dyslexic subject. Neither subject indicated improved comprehension as a result of therapy, in spite of the success of therapy on treated items.

Remediation of surface dyslexic, DF, established that he could be trained to read irregular words, however it was not apparent whether this indicated that orthographic representations had been established. Indeed, as discussed in Chapter 4 (section 4.1.3), the lack of generalisation to untreated words and the related language processing task might indicate that his orthographic strategy had not been affected by the intervention.

The interpretation that DF failed to qualitatively alter his processing strategy as a result of therapy is in agreement with the results of remediation of surface dyslexic subject RC reported by Seymour (1990a). RC failed to change his serial processing, phonological strategy for reading as a result of remediation aimed at developing his orthographic lexicon. Seymour supported his conclusion by reference to measures of RC's reaction time to word and non-word stimuli made at the pre-intervention and post-intervention assessments. Measuring reaction time (or response latency) can give a direct indication of the strategy operating in single word reading (Seymour, 1986; Seymour & MacGregor, 1984). In the present study response latencies were not assessed so it was not possible to determine directly whether DF's increased performance on the treated irregular words coincided with a change in processing strategy. A change towards a whole word processing strategy would have been accompanied a reduction in response latency. If DF, like

RC, continued to employ a phonological strategy which entailed serial processing, response latencies would have been related to the length of the stimulus.

DF's results are consistent with the interpretation that his reading strategy did not undergo qualitative modification as a result of therapy. However they are also consistent with the interpretation that his reading strategy did undergo a qualitative change, but that this change was not detected by the measures employed in the study. Measures of response latency would have clarified this issue.

Although the results of DF's remediation seem to resemble those of RC (Seymour 1990a) in that therapy failed to alter his processing strategy, DF's performance on untreated items as a result of remediation differed from that of RC. DF showed no effect of treatment on the untreated items, whereas RC's performance on untreated items did improve. An explanation for this difference in results is suggested by Seymour, who explains that the methodology employed in his study may not have allowed for the effects of therapy to be separated from confounding effects such as experiences in the home or at school. Thus, the increase in performance on untreated items shown by RC may have been the result of a generalised effect of being in therapy or spontaneous maturation, rather than a specific effect of the treatment. The design of the present study did allow isolation of the effects of therapy from such confounding effects by including multiple baseline measures as well as multiple pre-therapy and post-therapy assessments. Hence, it is feasible to postulate that the results of DF's remediation were congruent with those of RC, in that both subjects exhibited a significant influence of treatment on treated items but not on

untreated items nor on their reading strategies. This tentative correspondence invites further investigation especially in view of the theoretical implications of non-specific effects of therapy, discussed below.

An alternative explanation of the difference in the effects of generalisation of the effects of therapy for DF and RC might lie in the type of remediation undertaken. RC's remediation focused directly on establishing an orthographic lexicon, whereas this was only indirectly the focus of DF's therapy. DF was exposed to a specific programme designed to encourage visual processing of whole words. The generalisation of RC's treatment may have indicated orthographic development by establishment of sub-word units in an orthographic framework which could be utilised to read untreated words. In the long term, this might be expected to develop orthographic reading, whereas it is questionable whether this would be the case for DF. Relevant to this point is the age difference between RC (Chronological Age 9.2, Reading Age 7.3) and DF (CA 11.4, RA 9.4). Since DF was two years older than RC, his deviant compensatory strategies may be more ingrained and resistant to change than those of RC. Orthographic development might be more difficult to initiate in an older dyslexic subject than in a younger one, and therefore not apparent over the shorter period of this study.

The extent to which the effects of therapy generalised to untreated items is of theoretical importance for the interpretation of the organisation of the lexicon. Byng and Coltheart (1986) found that rehabilitation of their acquired surface dyslexic patient by treating irregular words not only improved performance on treated items but also had a non-specific effect on untreated items.

Coltheart and Byng (1989) note that two different theoretical models have been advanced to account for the functional relationship between the levels of word, letter and semantic processing. According to the item-specific model (Harris & Coltheart, 1986; Johnston & McClelland, 1980) words are represented by abstract word detectors which are specifically activated by a stimulus, while others are inhibited. In distributed-representation models (Hinton, McClelland & Rumelhart, 1986) specific words are not represented by unique word detectors, but by specific patterns of activation of across a network of abstract word elements. Based on computer simulations of learning in these networks, Coltheart and Byng (p.173) conclude that the non-specific effect of treatment observed with their surface dyslexic patient corroborated the view that "the visual word recognition system is based on distributed representations". Since this patient had acquired surface dyslexic symptoms, as a result of trauma, subsequent to developing skilled reading, it seems reasonable to assume that his treatment affected a fully developed but inadequately functioning orthographic lexicon.

In the case of remediation of developmental dyslexic RC, Seymour aimed to directly develop an orthographic lexicon. The results of RC's intervention, in particular the generalisation of the effects of treatment to untreated items, corresponded to those reported by Coltheart and Byng. Seymour suggested that this further supports a connectionist model of the lexicon, of the type he proposed, in which entries are combinations of sub-lexical elements. However, as noted above, there is some doubt about the validity of RC's results and they appear to contradict the results of the present study on this matter of generalisation of effects of treatment to untreated items.

If one accepts that remediation of RC did generalise to untreated items, while remediation of DF did not show any such generalisation, then an alternative explanation could be advanced in terms of the operation of different lexical strategies for reading. If RC did establish an orthographic strategy, operating on sub-lexical elements, while DF retained his deviant logographic strategy, then the differences in generalisation of the results of therapy to untreated items could arise because of differences in the organisation of the different lexicons. If an interactive model is accepted for the orthographic lexicon which did permit generalisation, then it is possible that an item-specific model is appropriate for the logographic lexicon which does not permit generalisation. The results of the present study would support this distinction since they are, as discussed earlier, consistent with the interpretation that DF continued to employ a logographic strategy following therapy. An implication arising from this distinction is that treatment of surface dyslexia should attempt to establish an orthographic lexicon directly by training phonologically motivated letter groupings, as suggested by Seymour (1990a), rather than adopting the whole word approach utilised in the present study.

It must be remembered that neither RC nor DF had developed an orthographic lexicon in the normal manner, hence their symptoms of developmental surface dyslexia. Seymour's dual foundation model stipulates that both alphabetic and logographic skills are necessary for orthographic development. RC and DF had both failed to develop orthographic reading, in spite of adequate alphabetic skills, so this failure was, presumably, due to inadequate logographic development. In view of the distinction made about the different

modes of operation of the logographic and orthographic lexicons, inadequate logographic development may not merely imply a visual memory deficit which fails to provide the visual foundations for an orthographic lexicon, but may indicate a fundamental inability to establish functional processing networks. The relationship between the logographic and orthographic lexicons awaits clarification.

Remediation of DF involved establishing orthographic representations for spelling the treated words and linking these to their semantic representations. Frith (1985) proposed that orthographic representations of words are established first for reading, and subsequently become available for spelling. Although spelling the treated items to dictation was an integral part of the remediation programme, the study focused on reading skills, so no formal assessment of spelling progress was included. Therefore, it was not possible to determine whether the treatment effects generalised to untreated items for spelling or produced a qualitative change in spelling strategy. If such effects occurred they should initially be detected in spelling and subsequently transfer to reading, once the orthographic representation established in the output lexicon becomes available to the input lexicon. Such results would have implications for practical implementations of remediation programmes as well as for the modularity of the models of developmental dyslexia. It is suggested that any future remediation study of developmental surface dyslexia should include assessment and monitoring of both reading and spelling.

In practical terms the failure of the therapy to affect DF's reading performance on the Comprehension task illustrates that DF gained little practical advantage as a result of therapy. One

explanation of this concerns the nature of the words incorporated into the remediation programme. Although their meanings were familiar, they were low frequency words which DF was unlikely to encounter in his everyday experiences with printed language. If he did not have the opportunity to utilise his newly established visual representations in his everyday reading tasks, the fact of their establishment would not motivate a change in his reading strategy or level of reading comprehension. To obviate this difficulty it is suggested that DF's practical application of reading skills could be improved if the treated items were relevant to his daily reading activities, ie. the irregular words which were treated should be those which he encountered in his everyday reading and writing, rather than the arbitrarily selected list utilised in the study. The highly specific effects of treatment shown in the study suggest that remediation would facilitate word recognition and spelling. However, whether such an improvement would entail eventual establishment of orthographic reading was not clear from the results of this study. It would require a longitudinal study over a longer period than the present one to determine this.

Remediation of phonological dyslexic, SP, succeeded not only in extending his knowledge of grapheme-to-phoneme correspondences but also in developing his underlying alphabetic reading strategy. It was suggested that the multi-sensory teaching strategy adopted during training encouraged phonological awareness and that this was responsible for improvement in phonological reading. To investigate this hypothesis it is recommended that a future study of remediation of phonological dyslexia should include tasks to assess and monitor phonological awareness (Goswami & Bryant, 1990).

The approach to remediation adopted in this study contrasted

with that of Seymour (1990a) whose remediation of developmental dyslexics RC and DK aimed to establish their orthographic lexicons directly, and did not focus on developing the prerequisite skills. The same intervention programme was administered to both subjects, one of whom was a phonological dyslexic while the other was a surface dyslexic. It is interesting to note that the Seymour's results of remediation of phonological dyslexic, DK, are similar to those obtained for SP, although the goal of DK's remediation was establishment of an orthographic lexicon, and for SP it was the extension of his knowledge of grapheme-to-phoneme correspondences. Both subjects responded to intervention by developing alphabetic reading strategies, corroborating the view that this is a necessary prerequisite for orthographic development and may not be omitted. The results of this study, therefore, provide further support for Seymour's dual foundation model of reading development.

The results of both this study and that of Seymour (1990a) seem to indicate that the interventions were more successful with the phonological dyslexic subjects than with the surface dyslexics, in that it was easier to mediate progress into an alphabetic stage rather than to the developmentally later orthographic stage of reading. One explanation of this might lie in the nature of the strategies. A phonological strategy which requires knowledge of a limited number of generalised grapheme-to-phoneme rules and the ability to segment words appropriately, whereas an orthorgaphic strategy requires the additional familiarity with a possibly infinite number of visual representations of words or word segments. It seems logical that remediation which successfully taught a few 'phonics rules' would have a greater effect on reading than remediation which successfully established a minute sub-set of all

the possible visual representations. This suggests that a remediation programme which focused on instruction in 'orthographic rules' or graphemic commonalities, while specifically highlighting the variety of corresponding pronunciations for the same grapheme, might be more efficacious. Such a programme might adopt a procedure similar to that employed in the present study with SP, but instead of focusing on the regularities of grapheme-to-phoneme correspondence, to focus on the exceptional and less frequently occurring ones.

It has become evident from research into cognitive neuropsychological rehabilitation of acquired language disorders that cognitive models of information processing are not sufficiently elaborated to indicate treatment strategies (Seron & Deloche, 1989). This difficulty is also evident in the area of developmental research. The most highly elaborated developmental model has been proposed by Seymour (1987, 1990b). Although surface dyslexic symptoms denote failure to develop an orthographic lexicon, there are a number of possible explanations for this failure. These include; a lack of available visual representations of word segments, arising from inadequate logographic development based on visual memory impairment, and failure to establish word specific modifications of grapheme-to-phoneme correspondences for irregular items. Phonological dyslexic symptoms denote failure to establish an alphabetic lexicon, which may arise from difficulty with phonological segmentation, with learning grapheme-to-phoneme correspondences or a combination of these. While it was not apparent from the present study which of these explanations were pertinent to the subjects treated, it is suggested that future studies in this area take cognisance of these distinctions in the

assessment and focus of remediation. In turn the results of such studies may help elucidate the relationship between these aspects of the model.

In conclusion, the methodology employed in the study efficiently isolated the effects of therapy. However the precise nature of these effects could be more stringently investigated in any future research in this area. It is recommended that a future study should include measurement of response latency to allow more specific determination of processing strategy, should consider phonological awareness and spelling strategies, in addition to reading strategies, and monitor both for changes as a result of therapy.

This investigation of remediation of developmental dyslexia attested to the advantage of the model-based psycholinguistic assessment for identifying the stage of reading acquisition at which development had become arrested, as well as for monitoring progressive development throughout the study. The efficacy of model-based remediation was established and practical suggestions both for teaching and for future research were advanced. In addition, the study highlighted areas, such as the nature of the the logographic and orthographic lexicons and the relationships between them and the alphabetic lexicon which have not been adequately specified in current developmental models of reading acquisition.

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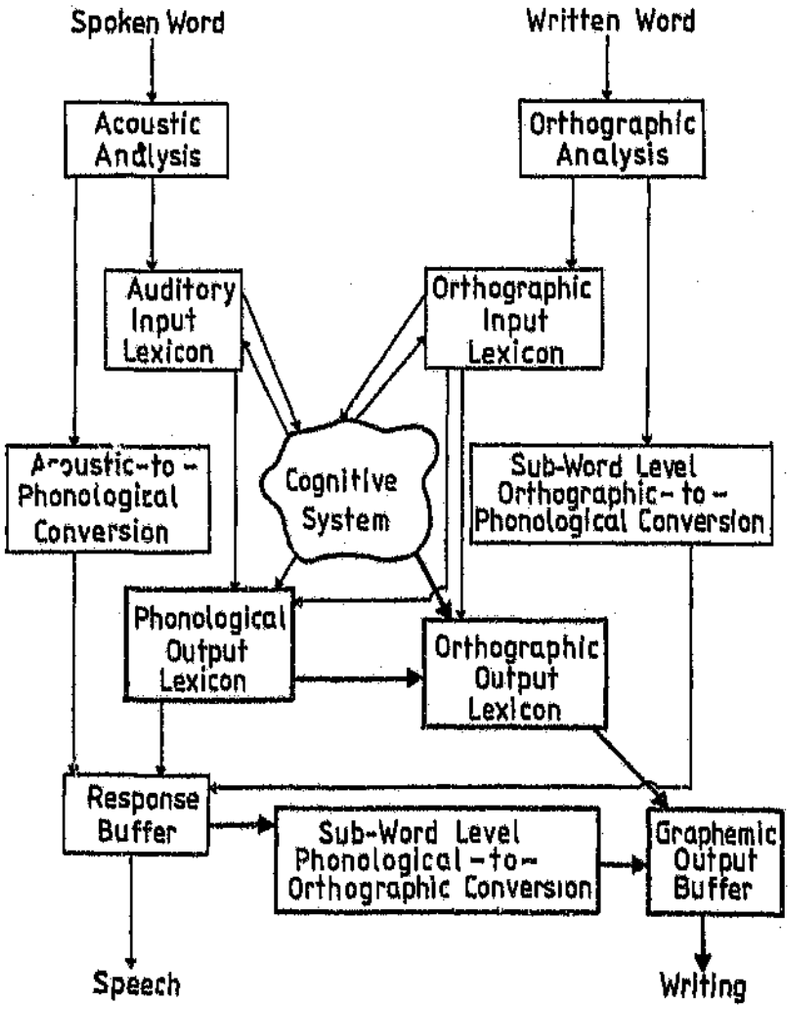
APPENDIX 1

INFORMATION PROCESSING MODEL OF READING



(Coltheart, 1987, p.274)

APPENDIX 2

Step	Reading		Writing
1a	logographic$_1$	⌊	(symbolic)
1b	logographic$_2$	⟶	logographic$_2$
2a	logographic$_3$	⌋	alphabetic$_1$
2b	alphabetic$_2$	⟵	alphabetic$_2$
3a	orthographic$_1$	⌊	alphabetic$_3$
3b	orthographic$_2$	⟶	orthographic$_2$

FIGURE 1. Six-step Model of Skills in Reading and Writing Acquisition (Frith, 1985, p.311)

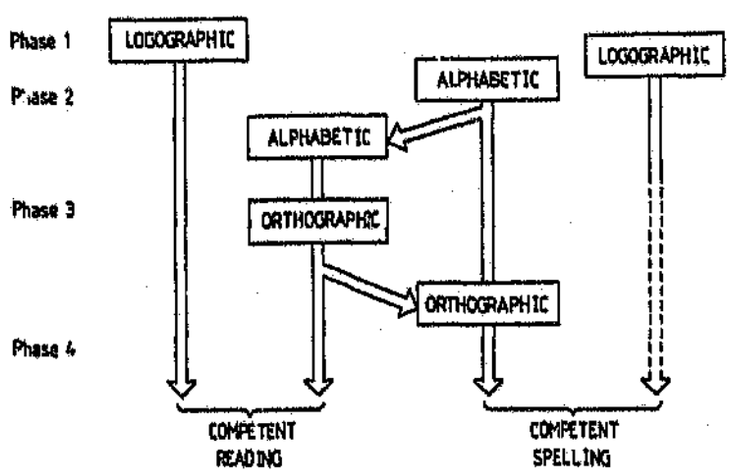


FIGURE 2. Schematic representation of model of reading and spelling development. The formulation differs from that of Frith (1985) in suggesting that logographic development may co-exist with alphabetic/orthographic development. (Seymour, 1987, p.354)

APPENDIX 3

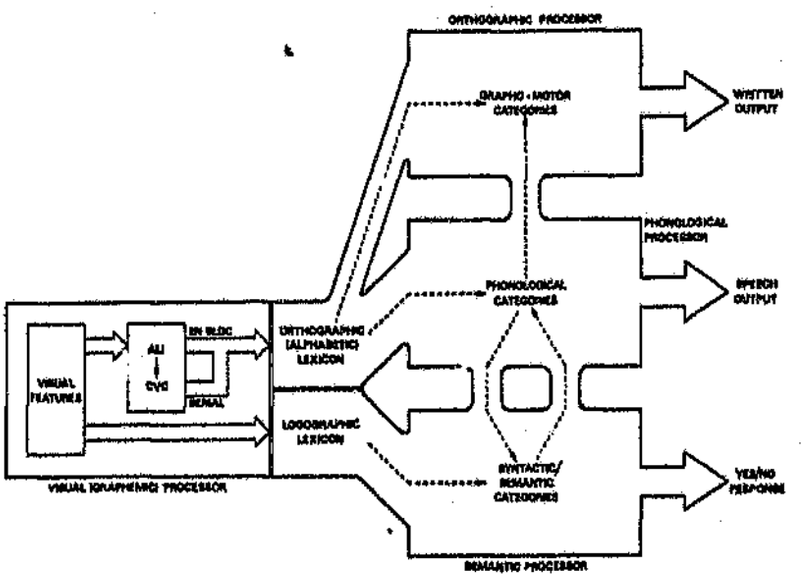


FIGURE 1. Dual lexicon information processing model (from Seymour & MacGregor, 1984)

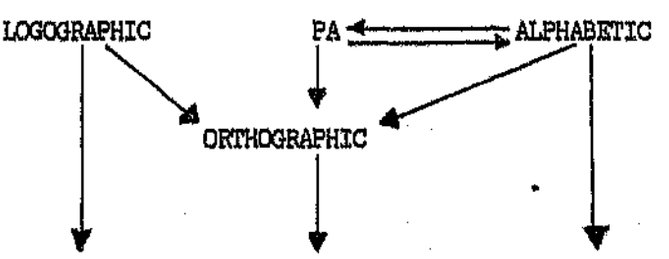


FIGURE 2. Dual Foundation Model (from Seymour, 1990a).

APPENDIX 4

Assessment Test Stimuli - Tests 1, 2 and 3.

Test 1 - Visual Lexical Decision			Test 2 - Auditory Lexical Decision			Test 3 Reading Aloud		
Word	Log Freq	Non-word	Word	Log Freq	Non-word	Word	Log Freq	Non-word
High Frequency Words			High Frequency Words			High Frequency Words		
girl	2.25	jirl	list	2.33	bist	road	2.2[illegible]	foad
rain	2.23	hain	ship	2.24	thip	fire	2.3[illegible]	kire
tree	2.41	pree	town	2.34	hown	moon	2.27	foon
note	2.02	lote	wife	2.01	bife	sand	2.04	vand
river	2.31	siver	music	2.18	fusic	party	[illegible].20	garty
blood	2.03	olood	eight	2.08	oight	child	[illegible].11	shild
start	2.32	plart	horse	2.32	torse	class	2.31	trass
north	2.10	gorth	glass	2.20	blass	plant	2.20	flant
square	2.15	square	street	2.12	spreet	spring	2.17	skring
notice	2.32	sotice	circle	2.16	mircle	island	2.01	illand
window	2.18	sindow	person	2.34	derson	garden	2.03	barden
forest	2.06	torest	object	2.07	onject	letter	2.38	ketter
general	2.04	meneral	million	2.00	killion	history	[illegible]	ristory
machine	2.13	rachine	surface	2.31	murface	trouble	[illegible]	frouble
village	2.07	hillage	brother	2.02	krother	present	[illegible]	gresent
problem	2.26	groblem	teacher	2.15	weacher	pattern	2.22	dattern
total	3.40			3.40			3.40	
mean	2.20			2.20			2.20	
SD	1.85			1.53			1.62	
Low Frequency Words			Low Frequency Words			Low Frequency Words		
wand	0.01	gand	mint	0.45	fint	yawn	0.26	rawn
jest	0.35	hest	bead	0.37	tead	curl	0.47	surl
pore	0.15	vore	wick	0.01	giok	quiz	0.10	juiz
silt	0.30	rilt	ford	-0.34	jord	tusk	-0.39	pusk
zebra	0.44	gebra	jewel	0.47	yewel	pedal	0.19	tedal
brute	0.12	trute	crumb	-0.40	grumb	aisle	0.24	oisle
winch	-0.52	dinch	stain	0.42	olain	pleat	-0.41	gleat
shrub	0.50	ohrub	baron	0.15	faron	flint	0.55	blint
plight	-0.09	glight	tripod	-0.02	pripod	troupe	0.02	broupe
mammal	0.55	jammal	salute	0.49	dalute	infant	0.80	onfant
bandit	0.00	mandit	splint	0.25	sklint	casket	-0.33	rasket
bonnet	0.22	fonnet	wigwam	-0.08	pigwam	clinic	0.25	plinic
gallery	0.30	jallery	gorilla	-0.09	borilla	novelty	0.08	sovelty
surgeon	0.38	murgeon	luggage	0.20	juggage	mansion	0.48	lansion
drizzle	-0.41	crizzle	vampire	-0.40	zampire	foundry	-0.46	houndry
carcass	0.16	harcass	penguin	0.46	senguin	sparrow	0.35	scarrow
total	1.44			1.44			1.44	
mean	0.24			0.24			0.24	
SD	-0.04			-0.02			0.04	

APPENDIX 5

Assessment Test Stimuli - Tests 4 and 5

REGULAR WORDS				IRREGULAR WORDS				NON-WORDS	
HIGH FREQ.		LOW FREQ.		HIGH FREQ.		LOW FREQ.		HIGH FREQ.	LOW FREQ.
word	freq	word	freq	word	freq	word	freq	word	freq
week	149	pest	1.48	walk	155	wand	1.30	salk	mand
base	145	peel	3.66	baby	133	wasp	3.66	haby	basp
sand	109	arch	3.93	iron	123	hymn	3.49	oron	tymn
hope	96	tile	3.49	lady	87	buoy	4.17	tady	luoy
note	105	reed	3.58	sign	108	tomb	3.82	zign	vomb
feel	227	duel	1.87	move	292	ache	1.72	gove	iche
help	738	rust	5.48	half	739	pint	4.90	galf	sint
ring	94	plug	6.74	bear	96	debt	6.55	zear	kebt
horse	208	gloom	3.88	group	266	steak	4.21	froup	theak
seven	125	slate	2.65	death	80	dwarf	2.20	leath	twarf
study	382	brood	2.46	money	308	gross	3.15	doney	fross
sheep	81	trout	7.21	blood	106	gauge	7.57	plood	dauge
dance	71	shrug	1.30	touch	74	cough	4.86	rouch	sough
order	268	choke	1.09	build	221	shove	1.79	puild	chove
happen	84	export	4.47	listen	150	soared	4.08	histen	voared
bottle	56	napkin	3.39	beauty	55	nephew	1.65	teauty	dephew
letter	238	manure	1.38	answer	330	orchid	1.22	alswer	erohid
simple	168	modest	5.64	broken	100	subtle	4.53	froken	gubtle
common	201	reptile	4.08	machine	134	butcher	4.72	bachine	hutcher
product	79	cartoon	2.22	islands	57	biscuit	2.04	aslands	fiscuit
total	3635		70.0		3644		69.5		
mean	173		3.50		174		3.41		
S.D.	153		1.73		154		1.82		
MAX	738		7.21		739		7.57		
MIN	56		0		55		0		

APPENDIX 6

Assessment Test Stimuli - Test 6

Regular words				Irregular words			
Homo-phone	Freq.	Non-homo-phone	Freq.	Homo-phone	Freq.	Non-homo-phone	Freq.
sun	352.0	room	348.0	where	1062.0	most	1078.0
here	340.0	thing	344.0	write	994.0	used	991.0
road	194.4	moon	186.0	piece	205.1	talk	200.0
plane	132.3	plan	137.6	eight	118.6	wrong	110.0
nose	91.4	ring	93.8	tied	66.2	blow	70.1
meat	87.5	safe	89.9	route	32.4	castle	30.0
deer	54.0	desk	56.4	roar	25.6	guard	26.1
flower	51.1	clock	55.3	pour	24.7	doll	23.9
rays	39.6	dream	39.0	soul	18.9	wolf	22.1
bare	35.1	pipe	38.0	sword	15.6	honey	17.9
pale	12.3	dare	13.6	pause	14.8	sweat	17.0
stare	10.3	camel	11.5	thrown	11.3	cousin	16.4
heel	5.0	save	5.5	patience	9.3	scissors	9.7
medal	3.9	barge	4.2	holy	6.4	bury	6.7
yoke	2.1	bunk	2.0	quarts	4.2	dread	4.3
slay	1.4	sash	2.9	vein	3.2	claw	3.0
total	1412.7		1417.9		2632.2		2626.1
mean	88.3		88.6		164.5		164.1
SD	110.3		106.8		334.4		333.0

APPENDIX 7

Spelling to Dictation - Stimuli and Responses

Word	Word Type	Word Freq.	Response DF	Type of Error	Response SP	Type of Error
talk	Irr Word	200.0	talk	-	talk	-
wrong	Irr Word	110.0	rong	PP	roing	UPA
blow	Irr Word	70.1	blow	-	blow	-
castle	Irr Word	30.0	castel	PP	cassle	PP
guard	Irr Word	26.1	gard	PP	god	V
doll	Irr Word	23.9	doll	-	ooll	-
wolf	Irr Word	22.1	wilf	UPA	wolf	-
honey	Irr Word	17.9	honey	-	honey	-
sweat	Irr Word	17.0	swet	PP	sweet	UPA
cousin	Irr Word	16.4	cuson	PP	cussen	PP
piece	Irr Hom	205.1	pees	PP	pices	V
eight	Irr Hom	118.6	eight	-	eigith	V
tied	Irr Hom	66.2	tide	PP	tide	PP
route	Irr Hom	32.4	root	PP	root	PP
roar	Irr Hom	25.8	roaw	PP	raw	UPA
pour	Irr Hom	24.7	poar	PP	pore	PP
soul	Irr Hom	18.9	sol	PP	sole	PP
sword	Irr Hom	15.6	sard	PP	swrod	V
pause	Irr Hom	14.8	poazs	PP	porss	UPA
thrown	Irr Hom	11.3	thon	UPA	togthen	V
past	Reg Word	196.0	parst	PP	passed	PP
plan	Reg Word	137.6	plan	-	plan	-
ring	Reg Word	93.9	ring	-	ring	-
safe	Reg Word	63.9	safe	-	save	UPA
desk	Reg Word	56.4	desk	-	desk	-
clock	Reg Word	55.3	clok	PP	clouck	UPA
dream	Reg Word	39.0	dreem	PP	drem	PP
pipe	Reg Word	39.0	pipe	-	pipe	-
dock	Reg Word	13.9	dok	PP	doke	UPA
camel	Reg Word	11.5	kamel	PP	gamell	UPA
road	Reg Hom	194.4	rode	PP	rode	PP
plane	Reg Hom	132.3	plain	PP	plane	-
nose	Reg Hom	91.4	nows	PP	nose	-
meat	Reg Hom	87.5	meet	PP	meet	PP
deer	Reg Hom	54.0	deer	-	deur	UPA
flower	Reg Hom	51.1	flower	-	flower	-
rays	Reg Hom	38.8	rase	PP	rass	UPA
bare	Reg Hom	35.1	bear	PP	bear	PP
pale	Reg Hom	12.3	pail	PP	payle	PP
stare	Reg Hom	10.3	ster	UPA	stere	UPA
TOTAL ERRORS:	REGULAR WORDS			65%		65%
	IRREGULAR WORDS			75%		75%
PP = PHONOLOGICALLY PLAUSIBLE				89.3%		42.9%
UPA = UNSUCCESSFUL SOUND ATTEMPTS				10.7%		39.3%
V = VISUAL				0		17.9%

APPENDIX 8
Assessment Test Stimuli - Test 7

Regular Homophones

SOUND SAME					SOUND DIFFERENT				
Homophone	Log Freq.	Homophone	Log Freq.	GS	Homophone	Log Freq.	Homophone	Log Freq.	GS
tacks	0.358	tax	1.487	475	talks	1.107	tax	1.487	475
paced	0.338	paste	1.048	480	paved	0.776	paste	1.048	480
days	2.580	daze	-0.071	495	days	2.580	dame	-0.137	495
tail	2.040	tale	1.173	520	tail	2.041	tile	0.543	520
sail	1.720	sale	1.368	520	pail	1.425	pile	1.523	520
loan	0.629	lone	0.860	520	loan	0.629	lane	0.843	520
plain	1.767	plane	2.122	600	plain	1.767	plant	2.199	600
flea	0.540	flee	0.601	645	flee	0.601	fled	1.134	645
heel	0.701	heal	0.137	700	cheat	0.033	cheap	0.982	700
steel	1.877	steal	1.100	780	steal	1.877	stall	1.038	780
Total				5795					5735
Log Total Frequency			2.969					2.981	

IRREGULAR HOMOPHONES

knows	1.977	nose	1.961	216	grows	1.741	rose	1.895	216
war	2.155	wore	1.737	365	hot	2.338	hate	1.238	365
pour	1.392	pore	0.148	520	pour	1.393	pork	0.824	520
bare	1.545	bear	1.982	545	dare	1.134	dear	1.826	545
stake	0.713	steak	0.624	620	sneak	0.551	snake	1.543	620
bold	1.152	bowled	-0.638	663	bold	1.152	boiled	1.040	663
berry	0.346	bury	0.826	668	ferry	0.740	fury	0.845	668
board	1.978	bored	0.898	680	bread	1.886	bored	0.898	680
hall	1.678	haul	0.966	700	hail	1.678	heal	0.137	700
peace	1.727	piece	2.314	740	piece	2.314	price	1.660	740
Total				5719					5719
Log Total Frequency			2.997					2.973	

NON-WORD HOMOPHONES

afe		aif		387	afe		auf		389
voared		vored		855	voiled		voled		855
bauze		baws		466	bauze		bams		466
nime		nyme		700	nime		nume		700
queed		kweed		550	querd		smeed		550
soane		skain		380	soang		skain		380
aud		awd		567	ald		ard		567
keam		keem		700	kerm		keem		700
rabe		raib		520	rabe		ralb		520
zole		zoal		520	zolk		zole		520
Total				5645					5645

GS = Graphic similarity

APPENDIX 9

Assessment Scoring Sheets - Test 1

VISUAL LEXICAL DECISION

				RESPONSE	HIT	MISS	CR	FA					RESPONSE	HIT	MISS	CR	FA
mandit	non	LF	W / NW						carcass	word	LF	W / NW					
start	word	HF	W / NW						zebra	word	LF	W / NW					
square	word	HF	W / NW						pree	non	HF	W / NW					
jest	word	LF	W / NW						jammal	non	LF	W / NW					
forest	word	HF	W / NW						jirl	non	HF	W / NW					
bonnet	word	LF	W / NW						clood	non	HF	W / NW					
groblem	non	HF	W / NW						bandit	word	LF	W / NW					
hain	non	HF	W / NW						pore	word	LF	W / NW					
gorth	non	HF	W / NW						meneral	non	HF	W / NW					
silt	word	LF	W / NW						blood	word	HF	W / NW					
river	word	HF	W / NW						sindow	non	HF	W / NW					
ɟand	non	LF	W / NW						note	word	HF	W / NW					
north	word	HF	W / NW						wand	word	LF	W / NW					
torest	non	HF	W / NW						ohrub	non	LF	W / NW					
sotice	non	HF	W / NW						girl	word	HF	W / NW					
machine	word	HF	W / NW						window	word	HF	W / NW					
fonnet	non	LF	W / NW						vore	non	LF	W / NW					
rilt	non	LF	W / NW						gebra	non	LF	W / NW					
tree	word	HF	W / NW						crizzle	non	LF	W / NW					
problem	word	HF	W / NW						harcass	non	LF	W / NW					
jallery	non	LF	W / NW						dinch	non	LF	W / NW					
general	word	HF	W / NW						rain	word	HF	W / NW					
surgeon	word	LF	W / NW						notice	word	HF	W / NW					
gallery	word	LF	W / NW						village	word	HF	W / NW					
plart	non	HF	W / NW						murgeon	non	LF	W / NW					
rachine	non	HF	W / NW						mammal	word	LF	W / NW					
brute	word	LF	W / NW						equare	non	HF	W / NW					
shrub	word	LF	W / NW						hest	non	LF	W / NW					
piver	non	HF	W / NW						hillage	non	HF	W / NW					
lote	non	HF	W / NW						winch	word	LF	W / NW					
plight	word	LF	W / NW						glight	non	LF	W / NW					
drizzle	word	LF	W / NW						trute	non	LF	W / NW					
TOTAL									TOTAL								

WORDS HF CORRECT
HF ERRORS
LF CORRECT
LF ERRORS

NON-WORD HF CORRECT
HF ERRORS
LF CORRECT
LF ERRORS

CHI SQ.
HF WORDS vs HF NON-WORDS
LF WORDS vs LF NON-WORDS
WORDS vs NON-WORDS

CHI SQ.
VISUAL LEX. DECISION vs
AUDITORY LEXICAL DECISION
HF WORDS
TOTAL WORDS
HF NON-WORDS
TOTAL NON-WORDS

APPENDIX 10

Assessment Scoring Sheets - Test 2

AUDITORY LEXICAL DECISION

				RESPONSE									RESPONSE			
					HIT	MISS	CR	FA						HIT	MISS	CR	FA
sklint	non	LF	W / NW					penguin	word	LF	W / NW					
horse	word	HF	W / NW					jewel	word	LF	W / NW					
street	word	HF	W / NW					hown	non	HF	W / NW					
bead	word	LF	W / NW					dalute	non	LF	W / NW					
object	word	HF	W / NW					bist	non	HF	W / NW					
wigwam	word	LF	W / NW					oight	non	HF	W / NW					
weacher	non	HF	W / NW					splint	word	LF	W / NW					
thip	non	HF	W / NW					wick	word	LF	W / NW					
blass	non	HF	W / NW					killion	non	HF	W / NW					
ford	word	LF	W / NW					eight	word	HF	W / NW					
music	word	HF	W / NW					derson	non	HF	W / NW					
fint	non	LF	W / NW					wife	word	HF	W / NW					
glass	word	HF	W / NW					mint	word	LF	W / NW					
onject	non	HF	W / NW					faron	non	LF	W / NW					
mircle	non	HF	W / NW					list	word	LF	W / NW					
surface	word	HF	W / NW					person	word	HF	W / NW					
pigwam	nor	LF	W / NW					gick	non	LF	W / NW					
jord	non	LF	W / NW					yewel	non	LF	W / NW					
town	word	HF	W / NW					zampire	non	LF	W / NW					
teacher	word	HF	W / NW					senguin	non	LF	W / NW					
borilla	non	LF	W / NW					olain	non	LF	W / NW					
million	word	HF	W / NW					ship	word	HF	W / NW					
luggage	word	LF	W / NW					circle	word	HF	W / NW					
gorilla	word	LF	W / NW					brother	word	HF	W / NW					
torse	non	HF	W / NW					juggage	non	LF	W / NW					
murface	non	HF	W / NW					salute	word	LF	W / NW					
crumb	word	LF	W / NW					spreet	non	HF	W / NW					
baron	word	LF	W / NW					tead	non	LF	W / NW					
fusic	non	HF	W / NW					krother	non	HF	W / NW					
bife	non	HF	W / NW					stain	word	LF	W / NW					
tripod	word	LF	W / NW					pripod	non	LF	W / NW					
vampire	word	LF	W / NW					grumb	non	LF	W / NW					
TOTAL								TOTAL								

WORDS HF CORRECT
HF ERRORS
LF CORRECT
LF ERRORS

NON-WORD HF CORRECT
HF ERRORS
LF CORRECT
LF ERRORS

CHI SQ.
HF WORDS vs HF NON-WORDS
LF WORDS vs LF NON-WORDS
WORDS vs NON-WORDS

APPENDIX 11

Assessment Scoring Sheets - Test 3

READING ALOUD WORDS AND NON-WORDS

			CORR	ERROR				CORR	ERROR
rasket	non	LF			sparrow	word	LF		
clars	word	HF			pedal	word	LF		
spring	word	HF			foon	non	HF		
curl	word	LF			onfant	non	LF		
letter	word	HF			foad	non	HF		
olinic	word	LF			shild	non	HF		
dattern	non	HF			casket	word	LF		
kire	non	HF			quiz	word	LF		
flant	non	HF			ristory	non	HF		
tusk	word	LF			ohild	word	HF		
party	word	HF			barden	non	HF		
rawn	non	LF			sand	word	HF		
plant	word	HF			yawn	word	LF		
ketter	non	HF			blint	non	LF		
illand	non	HF			road	word	HF		
trouble	word	HF			gardan	word	HF		
plinic	non	LF			juiz	non	LF		
pusk	non	LF			tedal	non	LF		
moon	word	HF			houndry	non	LF		
pattern	word	HF			scarrow	non	LF		
sovelty	non	LF			gleat	non	LF		
history	word	HF			fire	word	HF		
mansion	word	LF			island	word	HF		
novelty	word	LF			present	word	HF		
trass	non	HF			lansion	non	LF		
frouble	non	HF			infant	word	LF		
aisle	word	LF			skring	non	HF		
flint	word	LF			surl	non	LF		
garty	non	HF			gresent	non	HF		
vand	non	HF			pleat	word	LF		
troupe	word	LF			broupe	non	LF		
foundry	word	LF			oisle	non	LF		
TOTAL					TOTAL				

WORDS HF CORRECT
HF ERRORS
LF CORRECT
LF ERRORS

NON-WORD HF CORRECT
HF ERRORS
LF CORRECT
LF ERRORS

CHI SQ.
HF WORDS vs HF NON-WORDS
LF WORDS vs LF NON-WORDS
WORDS vs NON-WORDS

CHI SQ.
VISUAL LEX. DECISION vs READING ALOUD
HF WORDS
LF WORDS
HF NON-WORDS
LF NON-WORDS

APPENDIX 12
Assessment Scoring Sheets - Tests 4 and 5

READING ALOUD - REGULAR AND IRREGULAR WORDS - NON-WORDS

	PRONOUNCIATION CORRI		ACTUAL		PRONOUNCIATION CORRI		ACTUAL		PRONOUNCIATION IRR	REG	ACTUAL
gauge	I	L	I	butcher	I	L	I	teauty	L	I	I
product	R	H	I	subtle	I	L	I	basp	H	I	I
shrug	R	L	I	rust	R	L	I	fiscuit	L	I	I
feel	R	H	I	hymn	I	L	I	alswer	H	I	I
half	I	H	I	common	R	H	I	tady	H	I	I
broken	I	H	I	baby	I	H	I	froup	H	I	I
cough	I	L	I	biscuit	I	L	I	tymn	L	I	I
trout	R	L	I	simple	R	H	I	puild	L	I	I
pest	R	L	I	walk	I	H	I	fross	L	I	I
money	I	H	I	buoy	I	L	I	vomb	H	I	I
base	R	H	I	tomb	I	L	I	plood	H	I	I
build	I	H	I	cartoon	R	L	I	theak	H	I	I
soared	I	L	I	letter	R	H	I	froken	L	I	I
arch	R	L	I	ring	R	H	I	sough	L	I	I
slate	R	L	I	islands	I	H	I	leath	L	I	I
machine	I	H	I	sign	I	H	I	dauge	H	I	I
move	I	H	I	ache	I	L	I	lucy	H	I	I
help	R	H	I	bottle	R	H	I	hutcher	H	I	I
answer	I	H	I	reptile	R	L	I	gove	H	I	I
note	R	H	I	happen	R	H	I	galf	H	I	I
bear	I	H	I	modest	R	L	I	chove	H	I	I
export	R	L	I	pint	I	L	I	bachine	L	I	I
sheep	R	H	I	debt	I	L	I	zear	H	I	I
dwarf	I	L	I	manure	R	L	I	mand	L	I	I
group	I	H	I	order	R	H	I	haby	H	I	I
beauty	I	H	I	sand	R	H	I	gubtle	H	I	I
hope	R	H	I	listen	I	H	I	salk	H	I	I
week	R	H	I	death	I	H	I	aslands	H	I	I
blood	I	H	I	dance	R	H	I	kebt	H	I	I
touch	I	H	I	napkin	R	L	I	doney	H	I	I
wasp	I	L	I	steak	I	L	I	voared	L	I	I
seven	R	H	I	shove	I	L	I	dephew	H	I	I
iron	I	H	I	brood	R	L	I	erchid	H	I	I
horse	R	H	I	peel	R	L	I	oron	H	I	I
lady	I	H	I	nephew	I	L	I	iche	H	I	I
wand	I	L	I	tile	R	L	I	histen	L	I	I
plug	R	L	I	gloom	R	L	I	sint	L	I	I
orchid	I	L	I	gross	I	L	I	zign	L	I	I
reed	R	L	I	choke	R	L	I	rouch	L	I	I
duel	R	L	I	study	R	H	I	twarf	L	I	I

REGULAR WORDS
HF CORR = /20 = %
HF ERR = /20 = %
LF CORR = /20 = %
LF ERR = /20 = %

IRREG. WORDS
HF CORR = /20 = %
HF ERR = /20 = %
LF CORR = /20 = %

TOTAL REG. WORDS :
CORRECT = /40 = %
ERRORS = /40 = %
TOTAL IRREG. WORDS :
CORRECT = /40 = %
ERRORS = /40 = %
TOTAL NON-WORDS :
CORRECT = /40 = %

APPENDIX 13
Assessment Scoring Sheets - Test 6

HOMOPHONE CONFUSION

		READING		DEFINITION		SPELLING	
		CORR	ERR/ACTUAL	CORR	ERR /ACTUAL	CORR	ERR/ACTUAL
past	Reg Word						
bare	Reg Hom						
deer	Reg Hom						
wolf	Irr Word						
bury	Irr Word						
here	Reg Hom						
holy	Irr Hom						
meat	Reg Hom						
medal	Reg Hom						
talk	Irr Word						
honey	Irr Word						
barge	Reg Word						
pause	Irr Hom						
piece	Irr Hom						
castle	Irr Word						
desk	Reg Word						
quarts	Irr Hom						
pipe	Reg Word						
sweat	Irr Word						
write	Irr Hom						
road	Reg Hom						
route	Irr Hom						
slay	Reg Hom						
soul	Irr Hom						
used	Irr Word						
stare	Reg Hom						
sword	Irr Hom						
camel	Reg Word						
safe	Reg Word						
sash	Reg Word						
thing	Reg Word						
dread	Irr Word						
eight	Irr Hom						
guard	Irr Word						
doll	Irr Word						
flower	Reg Hom						
heel	Reg Hom						
most	Irr Word						
save	Reg Word						
blow	Irr Word						
scissors	Irr Word						
nose	Reg Hom						
pale	Reg Hom						
patience	Irr Hom						
dream	Reg Word						
ring	Reg Word						
plane	Reg Hom						
pour	Irr Hom						
duel	Reg Word						

roar	Irr	Hom						
rays	Reg	Hom						
room	Reg	Word						
wrong	Irr	Word						
plan	Reg	Word						
claw	Irr	Word						
clock	Reg	Word						
sun	Reg	Hom						
cousin	Irr	Word						
dook	Reg	Word						
thrown	Irr	Hom						
tied	Irr	Hom						
vein	Irr	Hom						
where	Irr	Hom						
yoke	Reg	Hom						
			READING		DEFINITION		SPELLING	
TOTAL:	REG	HOM						
TOTAL:	REG	HOM						
TOTAL:	REG	HOM						
TOTAL:	REG	HOM						

APPENDIX 14

Assessment Scoring Sheets - Test 7

SILENT TESTS OF PHONOLOGY

REGULAR HOMOPHONES

					H	M	CR	FA
tail	tile	SD	S	/D	:	:	:	
tacks	tax	SS	S	/D	:	:	:	
flea	flee	SS	S	/D	:	:	:	
dame	days	SD	S	/D	:	:	:	
flee	fled	SD	S	/D	:	:	:	
plain	plane	SS	S	/D	:	:	:	
loan	lone	SS	S	/D	:	:	:	
plain	plant	SD	S	/D	:	:	:	
paved	paste	SD	S	/D	:	:	:	
heel	heal	SS	S	/D	:	:	:	
steal	stall	SD	S	/D	:	:	:	
tail	tale	SS	S	/D	:	:	:	
talks	tax	SD	S	/D	:	:	:	
pile	pail	SD	S	/D	:	:	:	
days	daze	SS	S	/D	:	:	:	
steel	steal	SS	S	/D	:	:	:	
cheat	cheap	SD	S	/D	:	:	:	
paced	paste	SS	S	/D	:	:	:	
loan	lane	SD	S	/D	:	:	:	
sail	sale	SS	S	/D	:	:	:	
		TOTALS			:	:	:	

IRREGULAR HOMOPHONES

					H	M	CR	FA
dare	dear	SD	S	/D	:	:	:	
knows	nose	SS	S	/D	:	:	:	
board	bored	SS	S	/D	:	:	:	
pour	pork	SD	S	/D	:	:	:	
bread	bored	SD	S	/D	:	:	:	
berry	bury	SS	S	/D	:	:	:	
bold	bowled	SS	S	/D	:	:	:	
ferry	fury	SD	S	/D	:	:	:	
hot	hate	SD	S	/D	:	:	:	
hall	haul	SS	S	/D	:	:	:	
piece	price	SD	S	/D	:	:	:	
bare	bear	SS	S	/D	:	:	:	
grows	rose	SD	S	/D	:	:	:	
sneak	snake	SD	S	/D	:	:	:	
pour	pore	SS	S	/D	:	:	:	
peace	piece	SS	S	/D	:	:	:	
hall	heal	SD	S	/D	:	:	:	
war	wore	SS	S	/D	:	:	:	
bold	boiled	SD	S	/D	:	:	:	
stake	steak	SS	S	/D	:	:	:	
		TOTALS			:	:	:	

NON-WORD HOMOPHONES

					H	M	CR	FA
zole	zoal	SS	S	/D	:	:	:	
bauze	bams	SD	S	/D	:	:	:	
scang	skain	SD	S	/D	:	:	:	
bauze	baws	SS	S	/D	:	:	:	
queed	kweed	SS	S	/D	:	:	:	
afe	aif	SS	S	/D	:	:	:	
ald	ard	SD	S	/D	:	:	:	
nime	nyme	SS	S	/D	:	:	:	
voiled	voled	SD	S	/D	:	:	:	
scene	skain	SS	S	/D	:	:	:	
kerm	keem	SD	S	/D	:	:	:	
keam	keem	SS	S	/D	:	:	:	
afe	auf	SD	S	/D	:	:	:	
rabe	ralb	SD	S	/D	:	:	:	
voared	vored	SS	S	/D	:	:	:	
rabe	raib	SS	S	/D	:	:	:	
aud	awd	SS	S	/D	:	:	:	
queed	smeed	SD	S	/D	:	:	:	
nime	nume	SD	S	/D	:	:	:	
zolk	zole	SD	S	/D	:	:	:	
		TOTALS			:	:	:	

APPENDIX 15

Assessment Scoring Sheets - Test 8

READING ALOUD

REGULAR WORDS	RESPONSE CORR\	ACTUAL	IRREGULAR WORDS	RESPONSE CORR\	ACTUAL	NON-WORDS	RESPONSE CORR\	ACTUAL
	TIME = ...			TIME = ...			TIME = ...	
cheat	\		hall	\		rabe	\	
cheap	\		heal	\		ralb	\	
lane	\		boiled	\		skain	\	
pile	\		snake	\		smeed	\	
tile	\		bear	\		nume	\	
paved	\		war	\		voiled	\	
plant	\		bury	\		ard	\	
dame	\		pork	\		bams	\	
stall	\		price	\		zole	\	
tail	\		dare	\		nime	\	
plain	\		ferry	\		ald	\	
pail	\		steak	\		queed	\	
loan	\		bold	\		scang	\	
tax	\		rose	\		auf	\	
fled	\		board	\		keem	\	
talks	\		knows	\		afc	\	
steal	\		piece	\		zolk	\	
days	\		pour	\		bauze	\	
paste	\		hate	\		voled	\	
flee	\		bread	\		kerm	\	
TOTALS	\			\			\	

REGULAR WORDS
CORRECT = /20 = %
ERRORS = /20 = %

IRREGULAR WORDS
CORRECT = /20 = %
ERRORS = /20 = %

NON-WORDS
CORRECT = /20 = %
ERRORS = /20 = %

APPENDIX 16

144 Irregular Words which were randomly arranged and presented to DF for reading aloud on three occasions during the Pre-therapy period of the study.

Word	* Freq.	Word	* Freq.	Word	* Freq.
chasm	0.09	cough	4.66	worse	30.05
thyme	0.10	gym	4.67	worry	33.24
typist	0.11	recipe	5.24	wool	35.83
adore	0.11	villain	5.27	orange	36.57
suede	0.21	angel	5.38	foreign	38.20
queue	0.30	colonel	5.55	quarter	42.70
beige	0.36	pearl	5.91	prove	45.07
crumb	0.40	lettuce	5.94	tongue	48.36
bruise	0.57	seize	6.28	rough	49.87
niece	1.06	sew	6.44	drew	52.09
pension	1.09	dough	7.21	usual	58.31
wrestle	1.10	schedule	7.31	liquid	61.93
geyser	1.22	pirate	7.71	fruit	66.23
spinach	1.34	chalk	7.83	pushed	68.89
guilt	1.37	diary	8.07	none	72.70
cleanse	1.54	marine	8.14	touch	73.92
chore	1.65	ballet	8.78	salt	75.28
tortoise	1.70	vehicle	8.78	shore	77.81
shove	1.79	fried	8.90	sugar	79.15
receipt	1.81	scissors	9.67	believe	82.86
cafe	1.98	chorus	9.80	lady	87.44
bough	2.18	stalk	10.16	ancient	91.85
resign	2.19	comb	10.17	quiet	92.13
sleigh	2.31	crude	10.21	pretty	98.34
gem	2.54	scheme	10.43	women	100.40
waltz	2.65	worm	11.28	science	100.93
eclipse	2.65	echo	12.06	minute	116.22
super	2.68	shepherd	12.07	business	121.08
heir	2.69	vegetable	12.63	store	122.42
trough	2.94	honest	13.38	strange	126.94
mansion	2.99	medium	14.24	ocean	134.14
onion	3.30	freight	14.45	natural	134.47
senior	3.35	mention	15.07	measure	145.25
mechanic	3.47	orchestra	17.17	music	151.38
disguise	3.48	shone	17.84	language	151.81
budget	3.67	uniform	18.00	friend	152.34
gown	3.77	clue	18.26	weather	166.34
tomb	3.83	muscle	18.73	heart	169.84
choir	3.87	ceiling	20.49	gone	187.53
parachute	3.88	flood	20.58	warm	187.93
steak	4.21	flour	21.08	group	286.05
plague	4.31	soup	21.68	sure	357.97
dread	4.32	autumn	22.31	above	437.70
fury	4.42	rhyme	22.34	should	628.42
coward	4.44	canal	23.44	before	1011.90
leopard	4.51	whistle	24.74	through	1056.20
chemist	4.53	washing	24.95	people	1344.10
exhaust	4.77	canoe	26.06	many	2262.60

* Frequency from Carroll, Davies and Richman (1971)

APPENDIX 17

Summary of Performance on Assessment Tests for Subjects and Reading Age matched Controls

Type of Task		Type of Stimuli		Percentage of Correct Responses			
				DF	Control Group	SP	Control Group
Reading Age (years)				9.42	9.22	6.75	8.48
Chronological Age (years)				11.42	9.27	11.17	8.34
					n=25		n=25
Test 1	Lexical Decision Visual	Words	n=32	78	81.1	72	77.1
		Non-words	n=32	81	88.9	44**	38.6
Test 2	Lexical Decision Auditory	Words	n=32	97	87.5	97*	87.2
		Non-words	n=32	97	93.5	60**	96.1
Test 3	Reading Aloud	Words	n=32	78	na	66	na
		Non-words	n=32	72	na	25	na
Test 4	Reading Aloud	Regular words	n=40	98	93.6	63**	89.2
		Irregular words	n=40	58*	74.7	50	68.7
Test 5	Reading Aloud	Non-words	n=40	95	84.7	27**	80.3
Test 6	Reading Aloud	Homophones	n=32	78	na	66	na
		Non-homophones	n=32	78	na	66	na
	Defining	Homophones	n=32	40	na	53	na
		Non-homophones	n=32	75	na	66	na
	Letter Naming	Homophones	n=32	100	na	91	na
		Non-homophones	n=32	97	na	94	na
Test 7	Silent Reading/ Decision	Regular words	n=20	85	na	80	na
		Irregular words	n=20	75	na	75	na
		Non-words	n=20	80	na	55	na
Test 8	Reading Aloud	Regular words	n=20	75	na	65	na
		Irregular words	n=20	70	na	80	na
		Non-words	n=20	75	na	25	na

na = data not available
* performance significantly different from Control group, $p<0.05$
** performance significantly different from Control group, $p<0.001$

APPENDIX 18
Subject DF - Items for Training

FIRST SET OF 33 TRAINING WORDS		SECOND SET OF 33 TRAINING WORDS	
word	word freq*	word	word freq*
TRAINING LIST 1		TRAINING LIST 4	
worm	11.28	scheme	10.43
vehicle	8.79	ballet	8.78
ancient	91.85	shore	77.81
queue	0.30	suede	0.21
resign	2.19	receipt	1.81
shove	1.79	guilt	1.37
through	1056.20	group	286.05
chalk	7.83	dough	7.21
minute	116.22	quiet	92.13
canoe	26.06	rhyme	22.34
mention	15.07	medium	14.24
TRAINING LIST 2		TRAINING LIST 5	
pension	1.08	niece	1.06
mansion	2.99	trough	2.94
pearl	5.91	colonel	5.55
mechanic	3.47	senior	3.35
shone	17.84	orchestra	17.17
touch	73.82	none	72.70
recipe	5.24	gym	4.87
cough	4.86	exhaust	4.77
parachute	3.88	choir	3.87
tomb	3.83	gown	3.77
ceiling	20.49	muscle	18.73
TRAINING LIST 3		TRAINING LIST 6	
measure	145.25	natural	134.47
quarter	42.70	foreign	38.20
geyser	1.22	wrestle	1.10
marine	8.14	diary	8.07
sew	6.44	seize	6.28
eclipse	2.85	sleigh	2.31
bruise	0.57	beige	0.36
scissors	9.67	fried	8.90
rough	49.87	prove	45.07
fury	4.42	plague	4.31
comb	10.17	chorus	9.80

* word frequency from Carroll, Davies & Richman (1971)

APPENDIX 18

Subject SP - First List of Regular words
88 words with frequency 0-50 from Carroll, Davies and Richmond (1971)

READING OF REGULAR WORDS-BASELINE

Word	Target Grapheme	Freq.	Word	Target Grapheme	Freq.
brand	A	8.28	peach	EA	11.18
strain	AI	10.10	bleak	EA	2.82
brain	AI	45.86	greet	EE	6.36
stair	AI	2.40	breeze	EE	22.80
claim	AI	20.16	stew	EW	8.65
flair	AI	0.15	fright	GH	9.80
tailor	AI	5.24	plight	GH	0.81
raid	AI	4.26	shrimp	I	3.78
daisy	AI	1.01	flint	I	3.53
paint	AI	38.63	yield	IE	7.77
spark	AR	12.02	brief	IE	24.63
lark	AR	2.70	lotion	ION	1.19
claw	AW	3.44	bride	I_E	7.89
stray	AY	5.56	strife	I_E	2.48
slay	AY	1.41	crime	I_E	7.06
shake	A_E	24.16	slide	I_E	32.43
grape	A_E	2.35	smile	I_E	46.3
tame	A_E	8.28	thrive	I_E	3.22
fate	A_E	9.25	knot	K	12.71
grave	A_E	11.95	rung	NG	3.66
spare	A_E	15.52	scooter	OO	0.54
fame	A_E	13.21	worn	OR	34.37
cherry	CH	13.05	bound	OU	29.73
chest	CH	37.09	drone	O_E	1.05
chin	CH	17.91	bone	O_E	42.47
churn	CH	2.36	mole	O_E	4.96
chicken	CH/CK	36.78	froze	O_E	2.80
quack	CK	1.78	graph	PH	32.91
pickle	CK	1.30	trophy	PH	0.91
blacken	CK	0.21	phantom	PH	0.42
freckle	CK	0.11	snorkel	SN	0.61
frock	CK	0.11	shrub	U	3.18
stock	CK	26.49	fuse	U_E	2.20
knock	CK	13.46	duke	U_E	1.96
critic	CR	1.46	amuse	U_E	3.32
crunch	CR/CH	0.83	tune	U_E	23.34
ridge	DG	12.26	refuse	U_E	8.99
badge	DG	1.58	costume	U_E	12.83
ledge	DG	9.05	whisper	WH	10.87
comedy	E	3.06	whisk	WH	1.33
delta	E	2.57	whistle	WH	24.74
merit	E	1.89	wriggle	WR	0.41
pleat	EA	0.04	wreck	WR	11.09
beard	EA	13.22	wrist	WR	10.24
leash	EA	2.08			

APPENDIX 20

Subject SP - Second List of Regular Words
Low frequency regular words containing 96 target stimuli.

word	word freq.	target grapheme
raisin	1.11	AI
wail	2.37	AI
stain	2.62	AI
quaint	2.40	AI
faith	7.87	AI
haunt	0.53	AU
fraud	0.72	AU
sauce	4.76	AU
haul	9.25	AU
launch	5.61	AU
fray	0.59	AY
hurray	1.62	AY
sway	4.02	AY
relay	5.99	AY
spray	9.08	AY
spade	0.71	A_E
flake	0.99	A_E
grape	2.35	A_E
slate	2.66	A_E
crane	6.90	A_E
munch	0.25	CH
launch	5.61	CH
leech	0.40	CH
choke	1.09	CH
thatch	1.53	CH
frook	0.11	CK
bracket	1.61	CK
snack	2.78	CK
rack	7.07	CK
buckle	2.53	CK
yeast	3.31	EA
scream	7.48	EA
preach	0.45	EA
cheat	1.09	EA
squeal	1.83	EA
keel	2.48	EE
deed	3.70	EE
jeep	5.64	EE
leech	0.40	EE
beetle	6.10	EE
siege	1.18	IE
shriek	2.26	IE
pier	5.60	IE
grief	6.31	IE
yield	7.77	IE
stripe	0.86	I_E
revise	2.65	I_E
vine	4.65	I_E
missile	6.84	I_E
slime	0.76	I_E

word	word freq.	target grapheme
mumble	0.66	LE
fable	3.47	LE
buckle	2.35	LE
beetle	6.10	LE
jingle	1.50	LE
hanger	0.60	NG
linger	1.67	NG
stung	3.53	NG
cling	5.53	NG
jingle	1.50	NG
croak	1.02	OA
boast	2.25	OA
foal	2.44	OA
foam	5.65	OA
oath	5.75	OA
spook	0.20	OO
droop	1.55	OO
groom	2.00	OO
brood	2.46	OO
spoon	7.89	OO
barrow	0.32	OW
bellow	1.28	OW
mow	2.45	OW
willow	7.17	OW
crow	7.86	OW
cope	1.83	O_E
poke	3.03	O_E
stole	7.48	O_E
choke	1.09	O_E
quote	1.40	O_E
phantom	0.89	PH
orphan	1.87	PH
aphid	3.23	PH
phase	5.19	PH
photo	6.17	PH
quilt	5.46	QU
quaint	2.40	QU
squeal	1.83	QU
quote	1.40	QU
squash	2.71	QU
faith	7.87	TH
thatch	1.53	TH
oath	5.75	TH
jute	0.43	U_E
duke	1.96	U_E
vulture	2.50	U_E
cure	7.54	U_E
fuse	2.20	U_E

NB some words contain more than one target grapheme.

APPENDIX 21

Subject SP - Analysis of Target Graphemes in the Second List of Regular Words

target grapheme	*prior prob.	*mapp freq.	*cond. prob.	number of words	total "word freq.	mean "word freq.
AI	0.0026	5	0.734	5	16.37	3.27
AU	0.0014	4	0.818	5	20.87	4.17
AY	0.0012	3	0.970	5	21.30	4.26
A_E	0.0111	7	0.651	5	13.61	2.72
CH	0.0045	3	0.640	5	8.88	1.78
CK	0.0026	1	1.000	5	14.10	2.82
EA	0.0047	8	0.576	5	14.16	2.83
EE	0.0026	2	0.979	5	18.32	3.66
IE	0.0011	5	0.492	5	23.12	4.62
I_E	0.0086	5	0.589	5	15.56	3.11
LE	0.0057	1	1.000	5	14.08	2.82
NG	0.0033	1	1.000	5	13.03	2.61
OA	0.0012	2	0.933	5	17.11	3.42
OO	0.0027	4	0.570	5	14.10	2.82
OW	0.0022	3	0.502	5	19.09	3.82
O_E	0.0043	7	0.785	5	14.93	2.99
PH	0.0022	1	1.000	5	17.35	3.47
QU	0.0022	2	0.878	5	13.80	2.76
TH	0.0051	3	0.732	3	15.15	3.03
U_E	0.0030	7	0.703	5	14.63	2.93

* prior probability, mapping frequency and conditional probability from Berndt, Reggia and Mitchum (1987)

" word frequencies of occurrence from Carroll, Davies and Richman (1971).

APPENDIX 22

Subject SP - Performance on Second List of Regular Words, indicating grapheme-to-phoneme correspondences selected for remediation.

	target grapheme	prior prob.	mapp freq	cond. prob.	number of words	mean word freq.	% correct responses
	Vowels						
*	A_E	0.0111	7	0.651	5	2.72	0
*	I_E	0.0086	5	0.589	5	3.11	40
*	EA	0.0047	6	0.576	5	2.83	40
*	O_E	0.0043	7	0.785	5	2.99	60
*	U_E	0.0030	7	0.703	5	2.93	20
*	OO	0.0027	4	0.570	5	2.82	40
	EE	0.0026	2	0.978	5	3.66	80
	AI	0.0026	5	0.734	5	3.27	20
	OW	0.0022	3	0.502	5	3.82	80
	AU	0.0014	4	0.818	5	4.17	0
	OA	0.0012	2	0.933	5	3.42	40
	AY	0.0012	3	0.970	5	4.26	40
	IE	0.0011	5	0.482	5	4.62	40
	Consonants						
	LE	0.0057	1	1.000	5	2.82	100
	TH	0.0051	3	0.732	3	3.03	100
	CH	0.0045	3	0.640	5	1.78	80
	NG	0.0033	1	1.000	5	2.81	80
	CK	0.0026	1	1.000	5	2.82	80
	PH	0.0022	1	1.000	5	3.47	40
	QU	0.0022	2	0.878	5	2.78	100

* selected for remediation

APPENDIX 23

Subject SP - Training Tests

	First Training Set		Second Training Set	
	word	word freq.	word	word freq.
Test 1	Target A_E		Target O_E	
	scrape	7.00	quote	1.40
	pane	3.29	grove	5.81
	stare	10.28	dome	4.40
	rave	0.12	poke	3.03
	shave	1.75	robe	5.15
	crane	6.95	cope	1.93
	blaze	7.30	mode	4.84
	flake	0.97	choke	1.09
	slate	2 66	sole	5.15
	shame	8.56	arose	11.97
MEAN FREQUENCY		4.888		4.477
Test 2	Target I_E		Target U_E	
	crime	7.06	prune	0.89
	dine	1.33	duke	1.96
	stride	3.19	amuse	3.32
	lime	6.96	cute	3.86
	bribe	0.59	jute	0.43
	glide	3.98	cure	7.54
	stripe	0.86	fuse	2.20
	revise	2.65	vulture	2.50
	hike	5.85	crude	10.41
	thrive	3.22	cube	9.20
MEAN FREQUENCY		3.547		4.231
Test 3	Target OO		Target EA	
	spool	2.73	leash	2.08
	loom	5.56	streak	8.34
	brood	2.48	squeal	1.83
	roost	1.66	cheat	1.09
	hoot	1.16	gleam	4.07
	spook	0.20	tease	3.89
	scooter	0.54	scream	7.46
	moose	8.14	yeast	3.31
	droop	1.55	bleat	0.62
	hoop	6.34	preach	0.45
MEAN FREQUENCY		3.034		3.316

APPENDIX 24

Subject SP - Non-word Reading Responses

Target	Responses			
Trial	first	second	third	fourth
trass	trace	task	task	trace
frouble	furnble	fumble	burble	forble
skring	screen	c	sink	syringe
ketter	kettle	kitten	kettle	c
illand	c	c	island	c
gresent	greased	c	greent	c
garty	granty	c	karaty	c
shild	shaged	shied	shred	shield
ristory	c	restore	c	restore
barden	pardon	pardon	c	c
vand	c	vained	vend	c
foon	c	c	c	c
foad	food	c	c	food
dattern	c	c	c	c
kire	kree	creep	kree	knare
flant	c	c	flint	c
surl	skurl	scurl	skurl	shurl
gleat	greet	greatly	gently	gleant
lansion	lanson	landen	lawns	c
scarrow	square	score	sparrow	squirrel
rasket	risked	rust	rest	c
broupe	borrow	c	brop	c
houndry	youndry	haunder	c	c
juiz	quiz	c	joze	c
plinic	pint	pencil	pencil	plens
tedal	tendal	tebral	c	tremble
rawn	rown	c	c	c
pusk	c	c	pest	pask
sovelty	softer	safety	salty	salty
blint	bult	blight	betting	c
oisle	osold	osland	osill	c
onfant	c	onflat	onfute	c

c = correct response