Two Studies on the Effectiveness of Contiguous, Graphemic and Phonological Interventions on Measures of Reading and Spelling.

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Declaration

To my knowledge and belief, the work presented in this thesis is the original work of the author, except where acknowledgment in the text has been made to results supplied by previously published research. The material in this thesis has not been submitted, either in part or in whole, for a degree at this or any other university.

Signed ..Roger John Bourne..........

Date....8th November 2002.........

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Dedication

I dedicate this work to children having difficulties with phonological and phonemic awareness.

Abstract

Although research has established that phonological awareness is a predictor of future reading skill, the effects of variant vs. contiguous presentations of grapheme-phoneme correspondences have not been examined. Two studies including interventions were designed to determine the effects of two variant and one contiguous presentation of grapho-phonological information on reading and spelling outcomes. The design of three 10 hour interventions was identical across the conditions with the target stimuli being the only information to vary. The stimuli for the Phonemic intervention consisted of exemplar words that contained variant spellings of the same phoneme, those for the Grapheme intervention contained variant sounds of the same grapheme and those for the contiguous intervention consisted of sets of exemplars of identical grapheme-phoneme information. The dependent variables were five measures of reading and four tests of spelling.

Study 1 took place in a public school where a variety of teaching styles were evident. The participants were the members of three grade 2 classes and involved 76 children (*M* = 7 years 1 month and *SD* = 3.73 months) with 40 girls and 36 boys. The teacher of the Phonemic intervention class concentrated on teaching phonological awareness in her lessons. The Phoneme intervention class significantly ($p<0.05$) outperformed the Grapheme and Contiguous classes in reading regular and exception words, and listening comprehension. This suggests that intensive direct instruction in phoneme and phonological awareness contributes to the development of reading.

Study 2 took place in a denominational school where there was homogeneity of teaching style, assessment and instruction. The participants were members of three grade 2 classes and comprised 81 children (*M* age = 7 years 1 month with a *SD* = 4.70 months) with 37 boys and 44 girls. The second study reflected the benefits of the contiguous presentation of grapho-phonological information as the Contiguous intervention class significantly ($p<0.05$) outperformed both the Grapheme and Phoneme intervention classes in reading regular words, and spelling exception words and nonwords. This suggests that the presentation of contiguous grapho-phonological information contributes to reading and spelling outcomes more than variant presentations.

The results are interpreted in terms of the Dual Route Cascaded model (Coltheart et al., 2000) that postulates a rule-like behaviour of grapheme-phoneme correspondences.

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Chapter One AN OVERVIEW OF THE RESEARCH

1. The Research Domain

The irregular and capricious nature of English orthography is notorious (Barry & De Bastiani, 1997; Bowey, 1996; Bryant and Bradley, 1985; Plaut, McClelland, Seidenberg, & Patterson, 1996; Wagner and Torgeson, 1987). Words are categorised as regular, irregular, consistent, inconsistent, exception, ambiguous, unique etc., depending on the nature of their letter-sound correspondences. (For more information and definitions regarding the terms used in this thesis, please refer to the glossary.) Much research has addressed these different categories of words and how they affect children's error rates and response times (Bauer & Stanovich, 1980; Laxon, Coltheart, & Keating, 1988; Parkin, 1982; Parkin & Underwood, 1983; Schlapp & Underwood, 1988; Seidenberg, Waters, Barnes, & Tahenhaus, 1984; Stanovich & Bauer, 1978; Waters, Seidenberg, & Bruck, 1984). The fact remains that English orthography is complex and difficult to learn.

The psychometric perspective seeks to isolate the psychological mechanism(s) responsible for processing the complexity of the English alphabetic system (Coltheart, 1978; Coltheart, Curtis, Atkins, & Haller, 1993; Seidenberg & McClelland, 1989).

Other experimental research is directed at the pedagogical issue of the role of phonemes and other phonological units of speech in learning to read (Bryant & Bradley, 1985; Byrne & Fielding-Barnsley, 1989, 1991, 1993; Goswami & Bryant, 1990; Share, 1995; Tangel & Blachman, 1992). Research at an instructional level leads to a stage developmental model of learning to read and spell, that analyses the representations that children make during their developing attempts to map sounds to letters. These models trace the development of representations through a series of transitions from dissociated strings of letters with logographic content, to phonetically plausible attempts and eventually to orthographically correct spellings (Berninger, Vaughan, Abbott, Brooks, Abbott, Rogan, Reed, & Graham, 1998; Chall, 1979, 1983; Ehri and Wilce, 1985; Gentry, 1982; Henderson, 1981; Henderson, 1980; Read, 1975).

There is, however, no research that directly examines the efficiency different presentations of the relationship between orthographic and phonological information in a classroom context. This study engages students in exploring material pertaining to this relationship presented from different pedagogical approaches. The results of the study are discussed in the light of recent research, theoretical frameworks, and models of reading and spelling acquisition (Rastle & Coltheart, 1999a).

2. The Research Problem

The pedagogical practice of presenting children with grapheme-phoneme correspondences that reduce orthographic and phonological variance was termed by Beck and McCaslin (1977) the 'set for regularity' (see also Goswami, 1999), while they termed the presentation of grapheme-phoneme correspondences that reflected either orthographic or phonological variance as the 'set for diversity' (see also Greaney, Tunmer & Chapman, 1997a). Beck and McCaslin (1977) compared the effects of eight beginning reading programs on the development of code-breaking ability, where code breaking is understood as a similar skill to phonological awareness in that children learn to decode previously unsighted words by using their knowledge of frequent spelling patterns (Adams, 1990). Adams (1990) pondered the consequences of presenting grapheme-phoneme correspondences according to the "set for diversity" in contradistinction to the "set for regularity" and came to the conclusion that a "close presentation of alternate letter-sound correspondences seems to produce confusion; widely separated presentation interferes with the learning of the second" or variant grapheme-phoneme correspondences (Adams, 1990 p 253). Similarly, Beck & McCaslin (1977) argued that while the beginning reading programs that adopted an extreme set for diversity may produce confusion, those that are committed to a set for regularity position may be teaching a "partial truth" by exaggerating the level of regularity in the English alphabetic script (Beck & McCaslin 1977, p 31).

Goswami (1995) also recommended that vowel units where the sounds change, for example, the /ow/ sound in HOWL and SNOW, be taught on different days and consequently, separately.

This research investigated the effects of the presentation of grapheme-phoneme correspondences that contained orthographic variance or phonological variance or contiguous information on reading and spelling outcomes. The aim was to establish which presentation, if any, facilitated literacy outcomes and to discuss the cognitive processes that were involved.

3. Phonological and Orthographic Variance

The alphabetic principle brings together the phonological and orthographical processes to map graphemes to phonemes. A mastery of the alphabetic principle is essential for the phonological recoding of print whereby novel strings of graphemes are converted to speech.

Phonological variance occurs when the same grapheme represents different phonemes. For example, the grapheme 'a' is a short /a/ sound in the word AT, a long

/a/ sound in the word NAVY, a short /o/ sound in the word WANT and an /ar/ sound in the word PATH (Spalding & Spalding, 1969). Phonological variance is responsible for the generation of homographs for example, LEAD (as in, "I lead a quiet life", and "this battery is made of the metal, lead") which are words that share the same spelling, but have different pronunciations. Rastle and Coltheart (1999b) call these representations 'homographic heterophones'.

Orthographic variance occurs when the same phoneme can be represented by different graphemes. For example the long /a/ sound can be spelt with the letter *a* as in NAVY, or *a-e* as in RATE, *or eigh* as in WEIGH, etc. (Hanna, Hanna, Hodges, & Rudorf, 1966; Lamond & Whiting, 1992). Orthographic variance is responsible for the generation of homophones, for example, TO, TOO, TWO where words with different spellings share the same pronunciation and Rastle and Coltheart (1999b) call these representations 'heterographic homophones'. Orthographic and phonological variance is reduced by presenting target graphemes with a consistent phoneme, for example, in PAINT, MOUNTAIN, AFRAID, and EXPLAIN the long /a/ sound is consistently represented by the digraph AI, and in GROAN, SOAP, and ROAST the long /o/ sound is represented by the digraph OA (Brand, 1994). In this study contiguity will refer to the consistent presentation of grapheme and phoneme correspondences that avoids both phonological and orthographic variance (Greaney, Tunmer, & Chapman, 1997a). Venezky (1970) distinguished between major and minor correspondences on the basis of frequency of occurrence, morphology, etymology and spelling rules. The major or regular correspondences were generally those that occurred more frequently, and the minor ones were the exceptions or the less frequent correspondences. However, orthographical, grammatical, semantic and morphological considerations can take precedence over frequency (Treiman, Mullinnex, Bijeljac-Babic, and Richmond-Welty, 1995). Rime families are the best examples of instances where orthographic and phonological variance are minimised in the English language (Stanback, 1991,1992; Treiman, Mullinnex et al., 1995).

4. Theoretical Framework

Coltheart (1978) approaches this subject from a psychometric point of view. He postulates that there are at least two psychological mechanisms in operation when a subject is processing linguistic information: a lexical route that operates on word specific knowledge with a 'lookup' or dictionary procedure, and a nonlexical route that operates on grapheme-phoneme conversion rules. Coltheart (1978) predicts that an individual will select the route to word recognition that corresponds to the regularity of the orthographic information in the words. That is, regular or nonwords will be processed using the nonlexical route and irregular or exception words will be processed using the lexical route (Coltheart, 1978; Venezky, 1970). Coltheart wrote, "it seems highly likely that the next 20 years of cognitive psychology will be as dominated by the concept of 'strategy' as the past 20 years have been dominated by the concept of 'code'" (Coltheart, 1978 p. 199).

Coltheart's (1978) model of reading seems to attribute equal psychological value to graphemes and phonemes. Elkonin (1973) drew a distinction between graphemes and phonemes where graphemes were characterised as concrete, solid objects and phonemes as abstract and lacking objective reality. The fact that the stream of speech is not easily segmented into phonological units raises a new issue in the quest to identify the process by which linguistic information is acquired. The notion that phonemes are abstract units that are not readily identified may give way to some other units of language as being the basic recognisable psychological units of word identification. The integral identities of larger sound units including syllables and onsets/rimes are now considered by many researchers to be more accessible to beginner readers (Bryant & Bradley, 1985; Goswami & Bryant, 1990).

Glushko (1979) proposed that words are learnt by analogy and a single mechanism rather than by a dual-route lexical lookup procedure and a nonlexical rule-based procedure. In the analogy model novel words activate the image of visually similar words at a level proportionate to the degree of relatedness between the units and these in turn activate phonological information (Shallice and McCarthy, 1985). Glushko (1979) argued that orthographic and phonological information cannot be differentiated or dissociated since linguistic knowledge and linguistic mechanisms are inseparable. Consequently, words are learnt by a general content-free retrieval and analogical process.

Tunmer, Herriman, & Nesdale (1988) proposed that children use metalinguistic abilities whereby they reflect on and learn to consciously manipulate the phonological information of speech and apply it to the orthographic information of written language in addition to their epilinguistic abilities like speech that are acquired automatically. Normal language is an epilinguistic operation that comes automatically and effortlessly, while the linguistic operations of phonological awareness, spelling and reading seem to require the conscious application of strategies and are thus metalinguistic skills.

The implications of the pedagogical and psychometric issues so far alluded to will be discussed in the following chapters and an attempt will be made to explain the processes and mechanisms underlying the acquisition of reading and spelling skills.

5. Overview of the Anticipated Outcomes

This research aims to examine the effects of three different interventions on grade 2 children's reading and spelling development. The interventions were designed to develop the participants' phonological awareness and conscious attention to target phonemes. The first intervention, the Phoneme intervention, presents children with orthographic variance and seeks to examine whether their subsequent increased awareness of this phenomenon helps them develop strategies for word attack that are reflected in specific and standard reading and spelling tests. Does the cognitive activity of sorting and categorising words according to a targeted common sound help children to become aware of the phenomenon of phonological variance and consequently help them develop a metacognitive strategy that enables them to manipulate the sounds of words and retrieve their orthographic correspondences? Does the intervention enable the children to gain more control over words that contain phonological variance and help them adopt strategies to account for and compensate for this variance? Do they become more consciously aware of the alphabetic principle, find reading more understandable and develop strategies to approach novel words with more ease?

The second intervention, the grapheme intervention, presents children with phonological variance and seeks to examine whether their subsequent increased awareness of this phenomenon helps them develop strategies for word attack that are reflected in specific and standard reading and spelling tests. Does the cognitive activity of sorting and categorising words according to a targeted grapheme help children to become aware of the phenomena of orthographic variance and consequently help them develop a metacognitive strategy that enables them to manipulate the graphemes in words and retrieve their phonological correspondences? Does the intervention enable the children to gain more control over words that contain orthographic variance and help them adopt strategies to account for and compensate for this variance? Do they become more aware consciously of the alphabetic principle, find reading more understandable and develop strategies to approach novel words with more ease?

The third intervention, the contiguous intervention, is designed as a partial control on the other two interventions. The contiguous intervention presents consistent, but not necessarily regular grapheme-phoneme correspondences and mostly avoids confronting children with either orthographic or phonological variance. It is anticipated that an avoidance of variance in the language will minimise the opportunity for the students to develop strategies to cope with the inconsistencies contained in transfer tests (Spedding and Chan, 1994). (For further information and examples of lessons see APPENDIX A below.)

The interventions provided the participants with training in sub-word segmentation at the three levels of syllables, onset/rime and phonemes. The factors examined in this research were phonological or orthographic variance and the contiguity of grapho-phonological information with regard to their effects on students' reading and spelling outcomes. The first two interventions sought to present either orthographic or phonological variance to the students in a contained environment so that the students discovered the limits of grapho-phonological variance within the English language. It was anticipated that this awareness would facilitate the students' ability to approach novel words with flexibility and confidence.

The Phoneme intervention specifically addressed the phonological content of words and it was anticipated that this intervention in particular would sensitise children's awareness to sounds and help them to manipulate those sounds in relation to the orthographic content of the words, and that this would enable them to adopt metacognitive strategies to overcome the inconsistencies in the English language.

The contiguous intervention, on the other hand, would facilitate children's awareness of frequently occurring spelling patterns that would enable them to grasp the alphabetic principle. It was anticipated that the contiguous intervention would assist students in discovering consistencies and redundancies within the orthography and help them categorise words according to the morphological, semantic, phonological and etymological patterns that characterise the English script.

1. Disambiguation

The problem facing an individual learning to read the English language is the nature of the orthography itself. The English script has been variously described as quasi-regular (Plaut, McClelland, Seidenberg, & Patterson, 1996), notoriously inconsistent (Barry & De Bastiani, 1997), a very irregular system (Bryant and Bradley, 1985) and capricious (Wagner and Torgeson, 1987) and Bowey (1996) refers to the vagaries of English. Byrne, Fielding-Barnsley, & Ashley (1996) argue that the information processing of semantic, morphological and grammatical material reflects deep biological and innate structures while the nature of our orthography is culturally determined and easily influenced by current linguistic trends. De Saussure (1972) shows that there is "no necessary relation between sound and meaning" (p. 261) and that linguistic signs are arbitrary by nature. He writes that primitive people have the notion of language as "a habit, a custom analogous to dress and weaponry" (de Saussure, 1972, p. 261). Language is also subject to diachronic and synchronic laws. Diachronic laws relate to the historic formation and etymology of a language over time from its origins and synchronic laws relate to the social demands for linguistic compliance operating in a contemporary community (de Saussure, 1972; Seidenberg and McClelland, 1989).

The conventionally correct spellings of words are fixed in dictionaries and remain largely unchanged, while the pronunciations and meanings of these words are changing over time through contemporary usage, phonological shifts in accents and cultural circumstances. While the graphemic content of words is set in dictionaries, their sounds and meanings change according to cultural demands, and contribute to grapheme-phoneme correspondences remaining ambiguous and arbitrary. De Saussure's (1972) linguistic analysis suggests that the relationships between words and their meanings, and between graphemes and phonemes are arbitrary and culturally determined. Coltheart, Patterson, & Leary (1994) proffer the words COLONEL and BUSY as examples of extremely exceptional grapheme-phoneme correspondences, even for a "deep" alphabetic orthography like English.

Henderson (1981) traced the phonological shift in English vowels to King Henry VIII and the replacement of the Norman French and Latin languages with the English vernacular language in the Royal court. During the reigns of the Tudors and the Stuarts there commenced what is known as the great vowel shift where the grapheme-phoneme correspondences changed unevenly so that the long /e/ sound, for example, is represented by the letter 'i' (Scholfield, 1994; see also Henry, 1988). Read (1975) researched children's initial and spontaneous attempts at representing sounds with letters. He observed that children often revert to grapheme-phoneme correspondences that predate the 'great vowel shift' of the fifteenth century. Henderson (1980, 1981) considered these reversions an exemplification of Chomsky's thesis that language is innate and emanates from deep morphological structures rather than the relatively shallow, arbitrary and superficial systems of print.

Another source of spelling ambiguity in English is the manner in which vowels are modified by the consonants that follow them for example, the /a/ sound changes in the following rime families, CAT, MAT, HAT to CAR, FAR, STAR, to BALL, HALL, TALL. According to Goswami (1995) these changes are evidence that rimes are functional linguistic units that contribute to a reduction in the grapho-phonemic ambiguity in the English language.

The ambiguous or arbitrary grapheme-phoneme correspondences are a major hindrance to the learning of English. The aim of this research is to understand the ways in which this ambiguity is reduced and thus contribute to the pedagogical task of teaching literacy.

2. Phonological Processing the Core Deficit

Phonemic awareness is the ability to break words into their constituent phonemes whereas phonological awareness includes the ability to break words into syllables and intrasyllabic units (e.g., onset/rime). Deficits in these abilities consistently accompany language based learning difficulties (Bryant and Bradley, 1985; Gottardo, Siegel & Stanovich, 1997; Goswami and Bryant, 1990; Juel, 1988; Liberman and Shankweiler, 1985; Share, 1995; Snowling, 1995; Vellutino, Scanlon, & Sipay, 1997; Wagner & Baker, 1994, Wagner & Torgesen, 1987; Waring, Prior, Sanson and Smart, 1996; Yopp, 1992). Bryant and Bradley (1985) carefully analysed the implications of the accumulated research at that time. For example in their book, they examined the high correlation between reading difficulties and low verbal intelligence in a group of preschoolers who were posttested four years later. The post-tests indicated the same high correlations but the pattern of responses had changed so that the children with reading difficulties and poor verbal skills at post-test were not necessarily the same children as those identified when infants. Consequently, Bryant and Bradley (1985) realised that while verbal skills are a defining characteristic of reading difficulties, the cause of the difficulty still remained undiagnosed.

Bryant and Bradley (1985) discussed at length other possible variables related to reading difficulties, including time parents spent reading to and listening to their children read, letter reversals, intermodal crossing (e.g., from spatial to temporal sequences), visual, linguistic, word production and memory deficits. They were able to illustrate that all these factors were either defining characteristics or that the experimental design of the research made the interpretation of the results ambiguous. Bryant and Bradley (1985) argued that the mental-age match design was faulty. The mental-age match design matches children of the same age and differentiates them as either having or not having reading difficulties by a criterion that is then considered to be the cause of the difficulty that is, a positive result differentiates the two groups with the same mental age. However, the interpretation of this difference is ambiguous. If on the other hand, the two groups were matched for reading age then the results would indicate a causal factor. For example, research with letter reversals indicated that mental-age groups were differentiated into either demonstrating or not demonstrating this difficulty. When groups were matched on reading-age on the other hand, there was no significant difference for this factor. This indicates that letter reversal is a defining characteristic and not the cause of a reading difficulty because it is overcome with reading development.

Furthermore, groups that are matched for mental age that produce a negative result in that there is no difference between the groups also fail to establish a "cause" of reading difficulties. For example, research by Vellutino (cited in, Bryant and Bradley, 1985) matched groups of children with and without reading difficulties according to mental age on a task copying Hebrew letters designed to test for a visual deficit. The results indicated that there was no difference between the groups and thus demonstrated that a visual deficit is not a cause of reading difficulties but rather another defining characteristic.

Bryant and Bradley (1985) suggested that a third factor was involved and cited a growing body of research that indicates that children's inability to identify sounds and phonemes in words is the cause of reading difficulties.

Liberman, Shankweiler, Fischer, & Carter (1974) researched the ability of preschool, kindergarten and grade 1 children to tap out the number of syllables and the number of phonemes in words. Their research indicated that there is a gradient of difficulty from identifying syllables to identifying phonemes and that this correlates with age. Children when asked to "sound out" the word BAT are able to respond with three sounds like bu-ha-tuh but when asked to read the word BAT come up with a variety of incorrect responses. Liberman et al. (1974) conclude that children require instruction on how to break the alphabetic cipher and learn to segment words into phonemes and map these phonemes to the relevant graphemes.

Morais' (1987) research with ex-illiterate and illiterate adults in Portugal indicated that less than 20% of the illiterate adults were able to elide or add an initial consonant to a word while 70% of ex-illiterates were able to do the tasks. The illiterate adults were also significantly inferior to the ex-illiterates at detecting syllables. Read, Yun-Fei, Hong-Yin, & Bao-Qing, (1986) researched two groups of adult Chinese. One group was educated in China before the introduction of an alphabetic writing system and the other was educated on the alphabetic system of Chinese characters. The former group was unable to add or delete individual consonants in spoken Chinese words but the latter group could perform the task readily and accurately. It appears that phonological awareness and the ability to segment sounds does not follow spontaneously from cognitive and physical maturation, and does require reading instruction. Liberman and Shankweiler (1979) confirm Morais' conclusion that phonological awareness and the alphabetic principle need instruction and advocate the use of Elkonin's word boxes and the reiteration of words as a method of instruction in phoneme analysis, segmentation, sound sequencing and positioning.

The ability to read nonwords has become indicative of the use of grapheme to phoneme conversion rules (Coltheart, 1978) and the nonlexical or assemble route to reading. Nonwords by definition cannot be identified from previous exposure to print and require phonological awareness to be decoded. Bowey and Hansen (1994) compared a group of poor readers with younger readers using a reading age design and a group of average students using a mental age design, and the younger readers and the average readers both out-performed the poor readers on reading nonwords indicating that phonological awareness was the core deficit of reading difficulties.

Bryant and Bradley (1985) conducted interventions on a carefully selected and matched sample of 65, six years old children from Oxford, England. The children were pretested in both reading and mathematics to assess the effects of the interventions. The children were divided into four intervention groups and each intervention consisted of forty sessions. The first two groups were taught sound categorisation. The first group was trained in rhyme where they became sensitive to words that contained similar rhymes. For example, in the group of words NOD, RED, FED, BED, the word NOD is the odd one that does not rhyme with the others. They were also sensitised to alliteration, for example in the group of words SUN, SEA, SOCK, RAG only the word RAG begins with a sound that is different from the initial sound in the rest of the group. The second group was given instructions in the explicit connection between rhyme, alliteration, sounds and the manipulation of plastic letters. The third group was given instruction in categorising animals, concepts, and semantic information. The fourth group was taught nothing. The children in the second group that were given explicit instruction in sound-letter categorisation out-performed the sound categorisation group (the first group) by six months, the semantic group by ten months and the nil control group by fourteen months on standard reading and spelling tests. These gains were observed while mathematical development remained relatively constant indicating that the causal relationship between phonological awareness and reading is independent of general cognitive ability (Bradley, 1987; Wagner & Torgesen, 1987). Bradly and Bryant (1985) conclude that instruction in phonological awareness by teaching children to identify initial sounds and letters through alliteration and rime patterns by rhyme exercises is a causal factor in learning to read.

Stanovich, Cunningham & Cramer (1984) researched phonological awareness on a lean sample of fifty-eight kindergarten children on seven tests of phonemic awareness and three tests of rhyme. The correlation data indicated that the phonemic tests were more impressive predictors of reading ability than the IQ scores administered at the end of grade one. The phonemic variable accounted for 66% of the variance in reading ability. Stanovich et al. (1984) argued for a reciprocal relationship between acquiring reading ability from phonological awareness and acquiring phonological awareness from reading. Nevertheless, they affirmed that the causal relationship probably moves from phonological awareness to reading acquisition (Stanovich et al., 1984; Stanovich, 1986).

Bryant and Bradley, and their colleagues performed a longitudinal study over two years starting with 66 preschoolers and ending with 64 grade 1 children. The children were from the South of England and were selected from a wide range of social backgrounds (MacLean, Bryant and Bradley, 1987) (for further information see Methodology Chapter six 6:l). The first paper by MacLean, Bryant and Bradley (1987) reported a specific relationship between children's knowledge of nursery rhymes and phonological skills, and that the detection and production of rhyme and alliteration were related to the acquisition of early reading skills. Kirtley, Bryant, MacLean and Bradley's (1989) data indicated that children learn phonemic awareness from a sensitisation to and detection of the subsyllabic units of the onset and rime in words. They also established that the rime unit contributed more to phonological awareness and subsequent reading skills than the anti-body unit. Bryant, MacLean, Bradley, & Crossland's (1990) final paper included a multivariate analysis of data collected to differentiate between three different pathways leading from various subskills of reading acquisition, and reading and spelling outcomes. Their analysis confirmed that rhyme and alliteration contributed to the development of phoneme detection that subsequently leads to the acquisition of reading and spelling. The multivariate analysis did not confirm a pathway from reading and spelling to phoneme detection in the absence of any contribution from rhyme and alliteration skills.

Foorman, Jenkins and Francis (1993) researched twenty, first grade and twenty, second grade children on word segmentation, reading and spelling. The results indicated that an ability to phonemically segment the initial, medial and end sounds of words facilitated the reading and spelling of those words. Children that have difficulty segmenting an onset or a rime unit into its constituent sounds also have difficulty reading and spelling those words.

Foorman and Francis (1994) researched 40 first graders who were given 45 minute daily sessions of letter-sound instruction compared to 40 first graders who were given 15 minute daily sessions of letter-sound instruction. The main difference between the two groups was the amount of time committed to segmentation and letter-sound instruction. The pattern of spelling progress was from nonphonetic to phonetic to correct spelling and all children were observed to follow this progression but those that received additional letter-sound instruction progressed more quickly. Also, spelling was found to predict reading more than the converse. This research confirms that reading and spelling performance are directly proportional to the amount of instruction given to the development of segmentation skills.

Share & Gur's (1999) research on 30 preschool children indicated a causal relationship between alphabetic and phonological skills, and preschool word identification. The first part of their research investigated the strategies preschool children use to identify noncommerical print (e.g., student's names on lockers). These strategies processed contextual cues, visuo-graphic information, phonetic-cues, and alphabetic reading (Chall, 1983; Ehri and Wilce, 1987). Share & Gur (1999) observed that the children in this experiment focussed on most of the visual-graphic information in the strings and were dependent on the presence of this more complete information before the string could be identified. The results indicated that the children 4 years old, generally depended on contextual clues, while half of the children 5 years old, depend on a mixture of contextual and visual-graphic cues while the other half rely on phonetic-alphabetic cues. The distinctive impression given by this investigation is that preschool children are attentive to the complete graphic display of the information they are processing. The second part of this investigation includes an intervention. The 30 preschoolers were divided into a group that was trained in specific alphabetic skills including letter names and phonological awareness, a group that was trained in conventional concepts of print and a group that was trained in print concepts and code related skills. The results indicated that the children trained in phonological awareness made significantly greater gains in phonological awareness and letter knowledge, than the group trained in the conventional concepts of print. The print-concept and the code-concept group made significant gains in understanding the concept of print material but fell behind the phonological awareness group in alphabetic skills. Share and Gur (1999) made the comment that "collectively, these results point to the causal role of the alphabetic and phonological skills in the development of preschool word identification" (Share & Gur, 1999, p. 177).

Bradley (1987) concedes that phonological awareness helps children anticipate that words that sound alike may well be spelt alike, and yet may be unable to help them decipher homophones like *so, sow, sew* or *their, there*. Even so, phonological awareness has enabled children to grasp the alphabetic principle and learn that not every word requires word specific knowledge and that many words belong to families of consistent spelling patterns.

The current research is designed to examine and evaluate the effects of sound categorisation, and grapheme and phoneme variance on the acquisition of reading and spelling. This research seeks to extend and build on the existing research by a three-way comparison between the effects of phonological training, orthographic training and combined phonological and orthographic training. This comparison takes place in the context of phonological awareness training as the research is based on the premise that phonological processing is the core deficit in reading and spelling acquisition. Phonological awareness is understood to be the primary or causal deficit while deficits in other processes are considered as secondary or contributing factors. The contribution to learning difficulties of deficits in speech perception, working memory and precise lexical representations will now be discussed in the light of recent research.

3. Speech Perception

The phonemic components of words are not obvious to children and children require assistance in isolating the co-articulated phonemes in words. They are biologically equipped with speech perception that automatically and unconsciously processes words. The analysis of words into phonemes requires metalinguistic awareness that develops through reading instruction and experience. There is a reciprocal relationship between reading experience and phonemic awareness. That is, phonemic awareness contributes to reading acquisition while reading exposure contributes to phonemic awareness (Liberman and Shankweiler, 1985; Cunningham & Stanovich, 1993).

Speech perception may allow us to pronounce and identify spoken words differently from the way they are written. For example, the expression *'scuse me* is easily understood to mean 'excuse me', by our phonetic module that derives meaning from spoken words (Brady, 1997) but the written expression of the word requires it to be represented in an orthographically correct manner. The question arises as to whether or not this discrepancy between the way we speak and the way words are written causes spelling and reading difficulties.

Children with verbal dyspraxia and cleft palate have disordered and distorted word pronunciations and spelling difficulties. Children with a cleft palate represent words the way they pronounce them, for example, *sooner/soona, boat/bot* but children with dyspraxia produce phonologically disordered word representations like *year/andere, health/heens*. Both groups of children may have persistent speech and auditory processing disorders and may not be able to phonemically analyse words. According to the Dual Route model of information processing children with dyspraxia will become dependent on the direct visual memorisation of written words to acquire written expression and reading skills. The level of persistence of the speech disorder will also determine the level of receptiveness these children will have to training in phonological awareness (Stackhouse, 1985).

Snowling, Goulandris, Bowlby and Howell (1986) examined the speech perception of dyslexic children in a word repetition and auditory lexical decision task. There were three groups of British children a group of 10 years old children with dyslexia, a group of chronological aged matched normal readers and a group of reading age matched 8 years old children. Snowling et al's (1986) research indicated that the pattern of responses for both the word repetition task and the auditory lexical decision task could be explained as a deficit in phonological awareness and segmentation skills rather than a difficulty of speech perception and articulation or even short-term memory (Snowling, 1987; see also Stothard, Snowling & Hulme, 1996).

Snowling, Hulme, Wells and Goulandris (1992) reported a case study of an individual with developmental dyslexia known as JM when he was 13 and 14 years old. JM was a person with phonetic voicing and articulation difficulties that affected the phonological representations on which he organised his orthographic representations. His inadequate phonological representations were detrimental to his acquisition of spelling.

Further research by Snowling, Hulme, Smith and Thomas (1994) indicated that difficulties in speech perception affected the development of phonological awareness. The research was initially designed to examine the role of memory span on sound categorisation tasks where children 6-9 years old had to select the odd-one-out. Memory span did not contribute significantly to the sound categorisation task whereas phonetic characteristics did. In another experiment with the same children the phonetic characteristics of phonetic voicing or place of articulation, or both voice and place were presented to further investigate the relationship between phonetic similarity, working memory and sound categorisation. This research indicated that speech perception contributed independent and additional variance to that of phonological awareness, and affected the development of phonological awareness.

The quality of an individual's speech perceptions and phonological representations may affect a person's development of phonological awareness (Brady, 1997). A review of recent research on speech perception by Brady indicated that poor readers have more difficulty than good readers in repeating nonwords. Shared variance between nonword repetition skills and phonemic awareness may indicate that both are dependent on accurate speech perception (Brady, 1997). Children with good speech perception may be able to identify the constituent sounds in words more easily than children with imprecise phonological representations. Research by Brady and her colleagues indicated that children's speech perception increased with their development of phoneme awareness, and that children could have good speech perception and poor phonemic awareness, but once good phonemic awareness was attained speech perception improved. Consequently, they suggest that a focus on phonemic awareness may facilitate the acquisition of phonetic articulation (Brady, 1997). Speech perception seems to be dependent upon the phonological process of segmenting words into constituent sounds, whereby a reciprocal relationship is established and segmented sounds can be given more precise and distinct representations in speech. This line of argument is based on the premise that children begin by processing speech in large units or gestures and with instruction can begin to analyse the smaller units and phonemes (Brady, 1997).

Elbro, Borstrom and Petersen (1998) researched the relationship between phonological representations and the reading progress of 91 Danish children from their commencement of schooling at age 6 to the beginning of grade 2. Elbro et al. rate the Danish language as being a deep and opaque orthography similar to English and the grapheme-phoneme correspondences are determined by morphological as well as phonological influences. Indistinct phonological representations are characterised by incomplete, faulty, impoverished, under specified and variant pronunciations of vowel sounds in age appropriate polysyllabic words. The results indicated, "the quality of phonological representation of lexical items is an important and new predictor of the development of both phoneme awareness and phonological recoding skills in reading" (Elbro et al., 1998, p. 53).

Elbro et al.'s (1998) research indicates that impoverished phonological representations may contribute to the poor development of phonological awareness. The level of phonological representation being referred to can be illustrated by the word LOCOMOTIVE where the second vowel can be expressed as a long /o/ sound or as a short /u/ sound. The research measures the proximal distinctness of the pronunciation of a word to its written form, for example, the long /o/ pronunciation is more proximally distinct than the short /u/ pronunciation in LOCOMOTIVE. The experimental task required the children to correct a puppet's phonologically impoverished pronunciation to the orthographically correct pronunciation. Elbro et al. concluded that "indistinct representations may serve the purpose of everyday communication perfectly well, but may be very hard to segment into phonemes and use as the basis of further phonological manipulations" (Elbro et al., 1998, p.53). However, this may also imply that the pronunciation of a word changes with our exposure to print and the orthographically correct lexical representation of words rather than a development of speech perception.

Research by Treiman, Zukowski & Richmond-Welty, (1995) indicated that children's phonemic representations of words containing liquids and nasals like SINK can often be represented by the configuration SIK (for further information see on page 45) Treiman, Zukowsky et al. observe that the 'n' in SINK is being absorbed into the vocalic nuclei of the word and consequently is not subject to phonemic analysis and representation in its written expression. The research by Snowling et al. (1986) and Treiman, Zukowsky et al. (1995) indicates that speech perception is dependent upon the prior development of phonological awareness to detect the phonemes within words. On the other hand, the research by Elbro et al. (1998) indicates that the level of faulty phonological representations of word pronunciation correlates with other measures of phonemic awareness indicating that speech perception may contribute to difficulties in phonological awareness.

Another aspect of the relevance of speech perception to this research is that children tend to write words the way they say them. English words are often not written the way they are pronounced for example, OFTEN is pronounced 'of-en' but its spelling contains a silent 't' (Ehri, 1987; Ehri, Wilce & Taylor, 1987). Thus, there are two possible sources of discrepancy between the way words are pronounced and the way they are written. One may be that the anomalies in English orthography and the other may be the lack of precise phonological representations of spoken words that could reflect impoverished speech perception.

Joanisse, Manis, Keating and Seidenberg (2000) conducted a longitudinal study on a 137 children. Three subtypes of dyslexia were identified. There was a group with phonological dyslexia (PD), a group with developmental language impairment (LI) and a globally delayed group (GD). The pattern of reading impairment of the PD and LI groups was attributable to phonological deficits. The results indicated that a small minority of children with dyslexia have speech perceptual difficulties but that the main source of dyslexia is a deficit in phonological awareness.

The research indicates that phonological awareness and speech perception have a reciprocal relationship. Elbro et al.'s research indicates that impoverished phonological representations impair the development of phonological awareness. This is consistent with Treiman, Zukowski, et al's phonemic representation hypothesis that children represent words orthographically according to their phonemic analysis of those words. Even though there is an interaction between speech perception and phonological awareness the research indicates that a deficit in phonological awareness is the primary cause that leads to difficulties in the acquisition of reading and spelling skills.

4. Precise Lexical Representations

Another defining characteristic of reading and spelling is the acquisition of precise lexical representations of words as a part of the process of becoming literate.

At the level of orthographic reading, words are identified by word specific knowledge (Share, 1995). Andrews and Scarratt (1996) call this knowledge a precise lexical processing of the phonological and orthographic information contained in words. Here the plausible pseudohomophone 'caik' gives way to the precise lexical representation of the word 'cake'. These lexical representations are stored in memory and are retrieved accurately either as conventionally written expressions or as correct pronunciations.

Proficient readers and spellers are known to be able to retrieve precise lexical information independent of the context in which the word is found. Poor readers and spellers are known to be more dependent upon context and retrieve imprecise and under-specified representations of lexical information (Frith, 1980; Perfetti, 1995).

Andrews and Scarratt (1996) proposed that the retrieval of precise lexical representations by undergraduate students could be demonstrated using two tasks, repetition priming and neighbour priming. The repetition prime task consisted of the target word being presented as the prime. The neighbour prime task consisted of the presentation of a neighbour word that is one letter different from the target being presented as the prime. The anticipated result was that the proficient readers would respond more to the repetition prime than the neighbour prime and that the poor readers/spellers would respond more to the neighbour prime than the repetition prime where the repetition prime confirmed the precise lexical representations held by the proficient reader/spellers and the neighbour primes reflected the context dependent responses maintained by the poor reader/spellers. The results of the study confirmed these expectations, particularly in spelling where more precise lexical representations and efficient lexical-retrieval processes were evident in good spellers (Andrews & Scarratt, 1996). They concluded that precise lexical representations are a result of efficient lexical memory and retrieval, and are a predictor of proficient reading and spelling. Hence, the capacity for precise lexical representations is a defining characteristic in the acquisition of literacy.

The study undertaken as a basis for this thesis, with grade 2 children instructed all the participants in phonological awareness and then presented different interventions that focussed on different aspects of the alphabetic principle. One intervention addressed phonological awareness and anticipated that specific instruction in identifying variant sound-letter correspondences might contribute to reading and spelling outcomes. Another intervention addressed orthographic awareness and anticipated that specific instruction in identifying variant letter-sound correspondences might contribute to these outcomes. The third intervention only presented material that contained consistent and contiguous phonological and orthographical information in the context of phonemic awareness. The anticipation was that instruction in contiguous material would assist children to attain the alphabetic principle more than addressing either graphemic or phonemic variance.

5. Phonological Deficits and Working Memory

The role of memory as a defining characteristic of reading development has been researched by Gathercole and Baddeley (1990) and by Andrews and Scarratt (1996). Observations by Gathercole and Baddeley (1990) are cited to evaluate the possible effects of memory on the outcomes of this research.

The model of short-term working memory has three components the central executive and attentional system, and two slave systems, the visuo-spatial "scratchpad" and the articulatory loop. The scratchpad processes visual imagery while the articulatory loop specialises in the storage and rehearsal of phonological material (Baddeley, 1986). The central executive is activated when the multiple components of the cognitive architecture require coordination, and dysfunctions in the central executive occur when there is a processing deficit in the allocation of resources to the different cognitive processes (Swanson, 2000).

Gathercole and Baddeley (1990) proposed that a stable phonological representation of a word in the articulatory loop is necessary for the acquisition of vocabulary and language. They studied 6 children (*M* age 8 years) with language disorders and a control of developmentally normal children. Firstly, their results indicated that children with language disorders were poorer at nonword repetition than those in the control groups where nonword repetition requires phonological memory that is central to language development. Secondly, the results indicated that the children with language disorders lacked the skills to perform serial recall tasks that require storage of phonological information in the articulatory loop. The explanation for this was that the children with language disorders were experiencing either poor rehearsal processes or a reduction in their memory store capacity. Further experimentation was undertaken to differentiate between these alternatives. Thirdly the results indicated that the children with language disorders had a memory deficit for lists of words and nonwords. However, the children with language disorders could perform rehearsal processes and phonologically encode the material as efficiently as the normal children indicating that the source of their difficulty was in phonological memory. Finally the results indicated that there was no difference between the children with language difficulties and the normal children in their ability to perceptually discriminate and articulate speech. This research indicated that language disordered children have a specific deficit in phonological memory skills. The importance of this observation for the present study is that memory deficits do not appear to be the result of perceptual failures, or subvocal rehearsal or auditory discrimination, or articulation rate or a failure to phonologically encode material in memory, but rather of a phonological memory deficit that prevents the storage of phonological information (Gathercole & Baddeley, 1990). These observations also lend support to the proposition that phonological difficulties are the core deficit affecting literacy development. Phonological memory particularly affects the development of letter-sound correspondences and the rules that govern those relationships.

Snowling et al. (1994) also found that memory span does not contribute any independent variance in the sound categorisation research that they have performed. Research by McDougall, Hulme, Ellis and Monk (1994) on 69 British children of an average chronological age of eight years, also indicated that phonological ability (measured by rhyme awareness, phoneme deletion and speech rate) accounted for the variance predicting reading in a regression analysis. On the other hand, short-term memory (measured by verbal short-term memory) did not account for any independent variance.

Research by Swanson (2000) indicated a different pattern of results. Swanson assessed the retrieval of working memory on task involving three types of information, phonological (rhyming words), semantic (word categorisation) and visuo-spatial (arrangement of dots on a matrix). There were 84 students, 22 with learning difficulties, 32 in a chronologically age matched control group, and 30 in a reading level matched control group. The pattern of results indicated that children with learning disabilities were resistant to change and were affected globally in their central executive functioning and not locally in the specific phonological, semantic or visuo-spatial tasks. However, Swanson's use of rhyming tasks to assess phonological information rather than phoneme deletion and segmentation tasks may account for this variant pattern of results.

The research by Gathercole and Baddeley (1990), Snowling et al. (1994) and McDougall et al. (1994) acknowledges that a deficit in short-term memory is a defining characteristic of reading and spelling difficulties and also affirms that phonological awareness plays a primary role in the development and acquisition of literacy (Liberman and Shankweiler, 1985; Bryant and Bradley, 1985).

6. Summary of the Role of Phonological Awareness

The research reviewed in this chapter has demonstrated that the development of phonological awareness is the main predictor of reading and spelling acquisition. The present research is placed in the context of this research finding. The pedagogical significance of phonological awareness is that direct instruction in the alphabetic principle will facilitate reading and spelling acquisition. The present research incorporated phonological awareness training into the interventions of these studies to control for the effects of the development of phonological awareness and to focus the participants' attention on either the contiguous or variant grapho-phonological information.

Chapter Three READING MECHANISMS AND WORD IRREGULARITY

The present study is performed in the context of both pedagogical and psychometric frameworks. Share's (1995) Self Teaching Mechanism is based on current research and represents a pedagogical perspective. Psychometric research proposes three different models of reading:

1) one that is governed by two mechanisms,
2) one that is governed by a single mechanism and
3) one that is governed by two mechanisms interacting.

These different models will now be introduced along with the conceptual issues they engender.

1. An Overview of The Self Teaching Mechanism

The discovery that phonological awareness is connected to literacy acquisition provided the pedagogical community with a stratagem for dealing with the complexity of letter-sound correspondences in English. Share considers that direct instruction in traditional phonics would be unable to cope with the volume and complexity of the material associated with reading development. Direct instruction is accepted as a valuable teaching method but its fragmentary approach is unable to explain the learning experiences that children encounter in their exposure to the multitude of novel items present in the enriched literary environment of the classroom. Share also considers that the contextual guessing game of whole language instruction does not provide children with the tools necessary to map print to speech and vice versa. The possibility that phonological recoding acts as a self-teaching mechanism presents educators with a new strategy for instruction in reading acquisition (Share, 1995). Research by Bruck, Treiman, Caravolas, Genesee and Cassar (1998) compared a group of children educated in schools committed to the whole language approach to reading and spelling instruction with a group of children educated in schools committed to new phonics instruction. The children educated in new phonics significantly outperformed children educated in the whole language schools in word recognition, age appropriate spelling, the use of phoneme-grapheme strategies in spelling, and knowledge of conventional and orthographic constraints in spelling.

Share (1995) and Jorm and Share (as cited in Share, 1995) have proposed the Self Teaching Mechanism (STM) that combines research on protoliteracy and phonological awareness (Byrne and Fielding-Barnsley, 1989, 1991, & 1993; Tunmer & Nesdale, 1985), and the stage development theory of Ehri (1995) to produce literacy outcomes. The self teaching mechanism enables children to decode unknown words and to decipher words retained in their listening comprehension vocabularies by learning to fully analyse words into their constituent phonemes and to completely map the graphemes to the phonemes to produce a pronunciation of a known or a novel word. Good readers and writers attain fully specified phonological and orthographic representations of words. Partial or incomplete specification of words leads to poor literacy skills (Torgesen, Wagner & Rashotte, 1997). Exposure to print and contextual reading does not lead to the spontaneous acquisition of the alphabetic principle since the phonemic structure of words is an abstraction that remains elusive until it is objectified (Share, 1995).

A part of the Self Teaching mechanism is the strategy whereby children try out various vowel or consonantal sequences until the child identifies the pronunciation of a specific word in their inner lexicon or listening vocabulary. This may require repeated attempts at a word until it matches a genuine lexical item. A serial letter-by-letter reading, according to strict grapheme-phoneme correspondences, does not invariably lead to word recognition (Bloomfield and Barnhart, 1961; Harm and Seidenberg, 1999; Shallice and McCarthy, 1985). A self teaching mechanism of word recognition involves such a process of sounding out words and matching them to known speech (Calfree & Norman, 1998; Rack, Hulme, Snowling, & Wightman, 1994). Successful decoding and identification of words would add to the child's store of specific, orthographic and lexical information and act as a self-teaching mechanism. Apart from the use of consonants as silent letters, consonants are more stable than vowels and children can learn a strategy of trying out alternative pronunciations to determine a 'goodness of fit' whereby word recognition can be achieved (Castle & Holmes, 1996; Share, 1995; Treiman, Mullennix et al., 1995: Venezky, 1970).

Plaut et al.(1996) also point out that an irregular word like PINT is three-quarters regular. The three consonants are pronounced regularly but the vowel is irregular. Rack, Snowling and Olsen (1992) point out that the y and the t in YACHT have regular pronunciations and that phonological processing therefore plays a partial role in irregular word recognition.

Venezky (1970) wrote in the last paragraph of his classic book on the structure of English orthography,

> In the translation from spelling-to-sound words must be scanned.....Children should be told to scan left to right, letter by letter, pronouncing as he goes, or is there a more efficient scheme? In the first place, a person who attempts to scan left to right, letter by letter, ... pronouncing as he

goes, could not correctly read most English words. Many of the English spelling-sound patterns require, at a minimum, knowledge of the succeeding graphemic units. How, for example, is initial 'e' to be pronounced if the following units are not known (cf., erb, ear, ewer, eight)? This is just the beginning of the problem. In some patterns, the entire word must be seen and this is true of almost all polysyllabic words since stress patterns are significant for vowel quality. The implication is that a single pass left-to-right scanning is unproductive except for some monosyllabic words (Venezky, 1970, p. 129).

Here Venezky intuitively recognises that a vowel is influenced more by the consonantal environment that follows it than precedes it. This indicates that the process of phonological awareness and the strategies of word attack are subtler than a letter-by-letter serial sounding out of the grapheme-phoneme correspondences in a word.

2. Differences in Reading and Spelling

Another aspect of this subtle relationship of grapheme-phoneme correspondences is that almost every English word contains some word-specific information. This is caused by the redundancy in the grapheme-phoneme correspondences. This redundancy affects spelling more than reading. Researchers have observed that children perform better at reading than spelling (Andrews and Scarratt, 1996; Bryant and Bradley, 1985; Bryant, 1998; Frith, 1980). Initially, reading is best undertaken as a phonological recoding skill where words are phonologically analysed and synthesised to match known words, while spelling initially requires more visual memorisation of the specific orthographic patterns that constitute the precise lexical form of a particular word. Stanovich (1986) has postulated that there is a reciprocal relationship between reading and spelling (see also Snowling, 1994).

The potential for orthographic and phonological variance renders the unique spelling of a word unpredictable (Share, 1995). The inconsistency between the pronunciation of a word and its spelling is greater than that between the printed word and its pronunciation. The reading of a word by decoding graphemes to their corresponding phonemes is more regular than the various possible spellings (Barry & De Bastiani, 1997; Treiman, 1997). The Spalding and Spalding (1969) approach exploits the minimal redundancy in decoding from graphemes to phonemes relative to that in encoding from phonemes to graphemes. The information taken from the sound dictionary of the Lamond & Whiting (1992) material reflects the high degree of inconsistency in encoding from phonemes to their graphemic representations.

Intuitively these observations would anticipate that the Grapheme intervention would facilitate the acquisition of reading more than spelling and the Phoneme intervention would facilitate spelling more than reading acquisition. This implies that the phonological processing of words is more difficult when spelling and encoding, than when decoding and phonologically recoding words. Spelling requires a greater degree of precision in lexical representation than reading. Spelling requires full orthographic and phonological information whereas reading can function on partial cues and less precise representations (Andrews and Scarratt, 1996). Research by Foorman (1994) and Lundberg, Frost, and Petersen (1988) found that the development of phonological segmentation skills facilitated spelling acquisition more than reading.

3. The Self Teaching Mechanism as a Reading Mechanism

The self-teaching mechanism of learning to read requires children to attain a full analysis and knowledge of all the phonological, orthographic, morphological, semantic and syntactical information for competent reading to be mastered. Share (1995) argues that the self-teaching mechanism provides children with strategies that facilitate a translation of orthography to phonology that then operates as a scaffold for the phonological recoding of novel words. This implies that both the lexical and nonlexical routes are fully dependent on each other and activated simultaneously, although not equally, since the self teaching mechanism gives a crucial pre-eminence to phonological processes (Barron, 1986; Share, 1995; Zorzi, Houghton and Butterworth, 1998a). The following discussion of the different reading mechanisms will further explicate these processes.

4. A Review of Psychometric Reading Mechanisms

I. Two Mechanisms

The assumption that good decoders make good readers is implied in the Self Teaching Mechanism hypothesis. Freebody and Byrne (1988) researched 159 grade two and grade three children. The children were tested using nonwords and irregular words and were identified as adopting either a decoding strategy for reading or a word specific one. The former group, Freebody and Byrne called Phoenicians and the latter group Chinese readers. Their research indicated that the Chinese readers out-performed the Phoenicians in reading comprehension in grade 2, but by grade 3 the Phoenicians were outperforming the Chinese readers. Byrnes, Freebody and Gates (1992) re-tested the Chinese and Phoenician readers one year later and the results indicated that the Phoenician readers continued to make steady improvements in their reading and comprehension, whereas the Chinese readers deteriorated in their ability to read regular and irregular words, and demonstrated a shift to a decoding strategy in reading nonwords.

Snowling (1980) researched 36 nine years old normal readers that were matched on reading age and verbal IQ with 18 dyslexic readers (*M* age 12 years) on different auditory and visual discrimination tasks. The results indicated that normal readers use grapheme-phoneme conversion rules while the children with dyslexia seem to rely more on visual recognition skills or semantic factors (Snowling, 1980).

Research by both Castles and Coltheart (1993) and by Manis, Seidenberg, Doi, McBride-Chang and Petersen, (1996) indicated that two subtypes of dyslexia could be isolated in a sample of children with dyslexia. Castles and Coltheart's (1993) sample of children consisted of 56 children with developmental dyslexia and 56 chronologically matched normally developing children. Of the children with dyslexia ten scored below the 90% lower confidence limit for exception word reading while most of them 60% scored within one standard deviation of the age norm for nonword reading. Eight children scored outside the confidence limit for nonword reading but the majority 62.5% scored within one standard deviation of the age norm for exception word reading. Castles and Coltheart interpreted these results as indicating that there are two mechanisms involved in reading: the lexical route that processes exception words which require specific word knowledge, and a nonlexical route that processes nonwords which lack lexical content and relies on a grapheme-phoneme conversion mechanism. These researchers postulated a double dissociation between the two mechanisms whereby children with dyslexia either have surface dyslexia with a deficit in their lexical route, or have phonological dyslexia a deficit in their nonlexical route (Castles, 1994).

Manis et al.'s (1996) sample of children consisted of 51 children with dyslexia, 51 age-matched normal readers and 27 younger normal readers matched for reading age. They implemented the same statistical techniques as Castles and Coltheart (1993) and obtained regression analyses and a 95% confidence limit. At this confidence level, seventeen of the students with dyslexia exemplified a phonological deficit reflecting low scores in reading nonwords while maintaining normal levels of exception word reading. Fifteen of the students with dyslexia exemplified surface dyslexia by obtaining low scores on exception word reading while maintaining normal levels of nonword reading. These results replicated those of Castle and Coltheart, and indicated a dissociation between the two mechanisms. Manis et al., however, compared the children with dyslexia with the younger normal readers, and observed that the children with phonological dyslexia had a pattern of responses different from the younger normal students whereas the children with surface dyslexia had one similar. Manis et al. interpreted these results as indicating that students with phonological dyslexia have a deficit in their phonological processing of print while those with surface dyslexia are delayed in their acquisition of reading skills (see also Rack et al., 1992; Stanovich and Siegel, 1994). They further postulated that both forms of dyslexia are contingent upon a phonological deficit and suggest that a connectionist computational model consisting of a single mechanism could imitate these patterns of responses. That is, Manis et al. disagree that the results indicate the existence of two mechanisms (Manis et al., 1996; see also Metsala, Stanovich and Brown, 1998).

Research by Castles and Holmes (1996) challenges both Manis et al. (1996) and Share (1995) on their assumption that a phonological deficit is the predominant if not the sole contributor to reading difficulties. They isolated eight children with phonological dyslexia and eight children with surface dyslexia and administered an orthographic intervention consisting of analogical tasks to both groups. The children having poor lexical skills and surface dyslexia outperformed the children having poor sublexical or phonological dyslexia on word recognition tasks indicating a unique deficit for children with surface dyslexia in processing orthographic information (Castles and Holmes, 1996). This research supports Castles and Coltheart's (1993) double dissociation between the two mechanisms.

Evidence supporting those who propose a single mechanism will now be examined.

II. A Single Mechanism

The Dual Route theorists have generated evidence to support a dissociation between the phonological and orthographical processes of reading (Castles, 1994; Castles and Coltheart, 1993; Manis et al., 1996). Connectionist theorists including Manis et al. (1996) claim that the same evidence is better explained by a single route. The forerunner of the single mechanism model was Glushko (1979). Glushko's research demonstrated that children learn by analogy. Children categorise words by multi-letter spelling patterns. For example, Glushko demonstrated that inconsistent words like HEAD influenced children's pronunciation of nonwords like MEAD in an inconsistent way so that they rhymed with HEAD. This single analogical process acknowledges the inseparability of linguistic knowledge and linguistic mechanisms in reading. According to this model, phonological, orthographical, syntactical and contextual information form an integral part of a word's pronunciation. According to Glushko, the process of extracting rules from words becomes complex when consistent and inconsistent words are frequently encountered. The proliferation of rules required to account for the spelling of exception and regular words is unsustainable and can simply be replaced with a single mechanism that employs similar kinds of knowledge to recognise words. Processing by a single mechanism is further evidenced in the lexicalisation of nonwords and the regularisation of exception words. The single mechanism approach to reading does away with the distinction between regular and irregular words and categorises words as either consistent or inconsistent where one lexical mechanism accommodates the similarities and differences (Glushko, 1979).

The connectionist computational model of Seidenberg and McClelland (1989) proposed a single mechanism that has become known as the triangle interactive model or the Parallel Distributed Processing model. It consisted of pools of phonological, orthographical and semantic activation that contribute weights to a single mechanism that analyses consistently recurring patterns that form the basis of word knowledge. The implementation of this model demonstrates that word bodies contribute more to the learning of words and generalisation to novel words than individual sublexical units (For the development of these ideas, see page 63 below).

III. Both Mechanisms

The alphabetic principle and the deep orthography of the English language require processing mechanisms for both phonological and lexical knowledge (McGinness, McGinness, & Donohue, 1995). The relationship between these two processes is viewed differently by the various psychological and pedagogical theories on reading acquisition. Four factors that have contributed to these differences are automaticity in word recognition, the ubiquity of phonology, serial versus parallel processing of letters, and coarse and fine grain sublexical units.

i) Automaticity of Reading

The acquisition of a new skill often follows a developmental pattern beginning with the mastering of subskills and then progressing through a series of stages leading to the establishment of the skill. Once the skill is fully acquired it is performed seamlessly and automatically. The acquisition of reading is characterised by the mastering of the subskills of phonological and phonemic awareness, and the retrieval of word specific and orthographic knowledge then leads to the orthographic stage of fluent reading (Andrews and Scarratt, 1996; Bryant and Bradley, 1985). This process is often perceived as beginning with phonetic strategies and progressing to automatic retrieval processes (Andrews & Scarrett, 1996; Foorman, 1994; Share, 1995; Steffler, Varnhagen, Friesen, & Treiman, 1998). The implication is that once words have been fully analysed they are retained in an inner lexicon from which they can be retrieved automatically. On the one hand, this automaticity of word recognition can be a successful outcome of reading development but on the other hand, it raises the question of what processes trigger the retrieval of word specific knowledge. Particularly, is reading fluency a purely lexical and orthographic process as the above developmental processes imply, or are phonological, and perhaps morphological and other processes still required? Can meaning be attained directly from print without phonological mediation? The implication that fluent reading may not require phonological processing is challenged by research into the concept of the ubiquity of phonological processes.

ii) The Ubiquity of Phonology

There is growing evidence that phonological mediation is invariably activated during reading and spelling (Bosman & de Groot, 1996; Lukatela & Turvey, 1991 & 1993; Lukatela, Frost & Turvey, M., 1998; Treiman and Barry, 2000). Phonology determines the pathways that are activated in word pronunciation. The direct route passes from print to lexical retrieval to semantic representation and the articulation of the word. This route does not require phonological mediation except for the pronunciation of the word. The addressed route passes from print to phonological activation to semantic representation to the pronunciation of the word. In this route the phonological analogue of the word is activated rather than a process of assembled phonology. The assembled phonological route requires the parsing of print into grapheme-phoneme correspondences that are then blended to produce semantic activation and the pronunciation of the word (Bosman and de Groot, 1996; Bernstein and Carr, 1996). The research evidence that indicates the ubiquitous effects of phonology implies that the lexical model of reading, and hence pure instances of surface dyslexia, where reading takes place simply by lexical processes, is improbable.

iii) Serial and Parallel Processing

The Dual Route model proposes that unknown regular words are analysed serially from left to right via the nonlexical route. Irregular words and known regular words, on the other hand are recognised by the lexical route (Rastle and Coltheart, 1999b).

According to Rastle and Coltheart (1999b), the Parallel Distributed Processing (Connectionist) model of reading can be differentiated from the Dual Route model by the presence of the serial processing of letters. They consider that the serial processing effects are clear evidence for the existence of a nonlexical route to word recognition. The Connectionist model proposes that all words are analysed by a parallel process including orthographic, phonological and semantic information and that the serial reading of letters only eventuates when there is insufficient letter feature activation, necessitating frequent fixation on individual letters to achieve lexical and semantic activation (Behrmann, Plaut & Nelson, 1998).

Rastle and Coltheart (1999b) cite their research on the position of irregularity effect as evidence of serial processing. Research on undergraduate University students has demonstrated that left to right serial position of irregularity increases with difficulty in a monotonic and linear pattern. That is, if the first letter in a word like CHEF has an irregular grapheme-phoneme correspondence then it produces a longer response latency and higher error rate than words with an irregular correspondence in the third and final position like GLOW.

Research by Weeks (1997) examined the effects of the length of words and number of letters in words on both word and nonword naming latency. The subjects were a small sample of under-graduate university students. The pattern of results indicated that naming latency data were consistent with regularity effects and consistency effects. This research supports the existence of the non-lexical route of the Dual Route model and supports sequential and serial letter-by-letter processing of print (Weeks, 1997).

iv) Coarse and Fine Grain

Phonological awareness analyses a coarse grain or large unit of sound and phonemic awareness analyses a fine grain or small unit. Some researchers support the initial division of the syllable at the coarse grain level of the onset and rime units (Fowler, Treiman & Gross, Goswami, 1991; Goswami, 1993; Goswami & Bryant, 1990; Goswami & Mead, 1992; Kessler & Treiman, 1997; Treiman, Mullennix, Bijeljac-Babic, and Richmond-Welty, 1995; Wise, Olson and Treiman, 1990) whereas other research concentrates on the fine grain division of the syllable into phonemic units (Ball & Blachman, 1991; Muter, Hulme, Snowling & Taylor, 1998; Nation & Hulme, 1997; Rack et al., 1994; Rastle & Coltheart, 1998; Rastle & Coltheart, 1999b; Tangel & Blachman, 1992). There is also research evaluating the relative effectiveness of the different coarse grain units on reading acquisition, for example, the anti-body + coda compared with the onset + rime (Treiman, Mullennix et al., 1995). (A delineation of these subsyllabic units is available in the glossary.)

Children with learning difficulties need remedial help to progress from the coarse grain units and syllables to the fine grain units and phonemes (Foorman, Francis, Shaywitz, Shaywitz & Fletcher, 1997). Similarly, in the present research the interventions contained exercises that instructed and assisted children to parse words into the coarse grain units of syllables and onset/rime, and then the fine grain units of phonemes.

IV. Top down and Bottom up Models of Reading

Theories of reading can be placed in a continuum according to their evaluation of the role of phonics and decoding in reading instruction. The whole language approach adopts an extreme top-down position where decoding is considered to be detrimental to the acquisition of reading. At the other extreme are the bottom-up theorists who advocate explicit instruction in decoding and the structured teaching of letter-sound correspondences. In between these two extreme positions are the 'interactive' theorists who claim to incorporate the strengths of both the top-down and bottom-up theorists (Badenhop, 1993, Stanovich, 1980).

The top-down or whole language theory treats reading as a "psycholinguistic guessing game" (Goodman, 1967, p.127). Reading is not the common sense perception of letters or words, but the interaction of thought and language that develops the ability to anticipate and predict meaning from the text. The process is a complex phenomenon of sampling the text for graphic cues and making semantic and syntactical syntheses that produce meaning and the anticipation of further meaning lying ahead (Goodman, 1967; Goodman & Goodman, 1979). Goodman based his theory on observations of a fourth grade child reading from a sixth grade basal reader. The miscues and substitutions of the child seemed to indicate that he/she was not processing a sequence of perceived words but was reconstructing meaning by guessing and other linguistic strategies. Goodman concluded that reading is not a process of decoding but a semantic and syntactical process of deriving meaning from text (Goodman, 1967; see also Newman, 1985).

This approach to reading makes no distinction between oral and written language. Initially, oral language processes phonological information at the surface level of ear/voice and listening/speaking, and then generates meaning via a deep structure of language at the semantic level. Initially, written language processes orthographic information at the surface level of eye/hand and visual input and then generates meaning via the same deep semantic and morphological structure of the language. Both oral and written languages are generated from the same deep innate structure of language and therefore are seen as naturally occurring phenomena. The deep language structure provides the 'function' of language that is purposeful, contextual, meaningful and social. The purpose of literacy is to gain comprehension. According to this theory, literacy development should take place in a literary enriched environment that presents words in a contextually relevant way. The social environment of the learner is also important. Children come to reading instruction with different levels of prior knowledge of literature that reflect the social value and cultural relevance given to literacy in their society (Goodman & Goodman, 1979; Wiseman, 1992). Words, letter-sound correspondences, parsing skills, grammatical knowledge etc., are seen as the form of language development. The proponents of the whole language theory assert "function precedes form in language development" (Goodman and Goodman, 1979, p. 137). The analysis of the bits and pieces of abstract phonological information in language is seen as a secondary and incidental development to the function of attaining meaningful comprehension from literature. In fact, a focus on decoding skills is considered to detract from and be detrimental to the development of literacy because it disregards literacy's function and consequently, hinders the motivation to read (Goodman & Goodman, 1979; Wiseman, 1992).

The bottom-up answer to the top-down theory of reading emphasises instruction in letter-sound correspondences. Phonics teaching relies on the reiteration of sounds and their association with symbols. English contains more sounds than distinct and unique symbols and this necessitates digraphs and polygraphs to accommodate the variety of sounds in spoken English. English also contains " 'unphonetic' words like was and done" (Flesch, 1955, p. 112) but the bottom-up theorists are not deterred from teaching phonics because of orthographic and phonological variance (Bloomfield & Barnhart, 1961; Flesch, 1955). They contend that a firm knowledge of the official or major letter-sound correspondences will prevent irregular words from producing confusion (Brand, 1994; Carnine & Silbert, 1979). Flesch's main criticisms of the top-down theory of reading is that it does not teach children how to spell, it allows children to guess at words and therefore disempowers children from learning to read for pleasure. The whole language movement gained ascendancy in 1908 when Dr. Edmund Burke Huey published an influential book advocating the method. Huey wrote, "reading to be truthful, must be free of what is on the page" (Huey, 1908 cited in Flesch, 1955) meaning that letters, words, phrases etc., are not the primary focus of reading.

Top-down and bottom-up theorists differ on the place of phonological awareness and the alphabetic principle (Perfetti, 1992; Stanovich & Stanovich, 1995). Phonics, which to bottom-up theorists is essential and fundamental, is to top-down theorists an irksome drudgery. Bottom-up theorists maintain that once children have mastered the code they can then read stories, fairy tales, myths and adventure stories that they like and it is top-down theorists who may be imposing drudgery upon children's education by binding them to reading texts containing a high degree of tedious repetition of simple words put together in ways that do not resemble normal English prose or expression (Flesch, 1955). Another factor that separates the two theories is the role of context. Research by phonological awareness theorists indicates that good readers do not rely primarily on context to read whereas poor readers rely more so. Good readers effortlessly recognise words in isolation and use context primarily for the interpretation of words and phrases (Perfetti, 1992; Stanovich, 1993; Stanovich & Stanovich, 1995). Research by the proponents of phonological awareness and the alphabetic principle also indicates that good readers attend to every word accurately and automatically, and do not approach words as a psycholinguistic guessing game (Perfetti, 1992; Stanovich & Stanovich, 1995).

The third reading theory is the 'interactive theory' propounded by Stanovich (1986). The model of reading acquisition presented in figure 1 can be used to illustrate the three theories (Adams, 1990; see also Seymour, 1987).

The 'top-down' theory to reading perceives learning as progressing from higher order meaning and contextual processes with minimal cues from the lower levels of phonology and orthography. The context processor informs the meaning processor of the coherence and predictable interpretation of the text, and the meaning processor organises the layers of connected meaning to derive comprehension (Adams, 1990). According to the top-down theory, learning at the orthographic and phonological level occurs on an incidental basis and deliberate instruction at this level disrupts the efficient processing of the preferred higher levels.

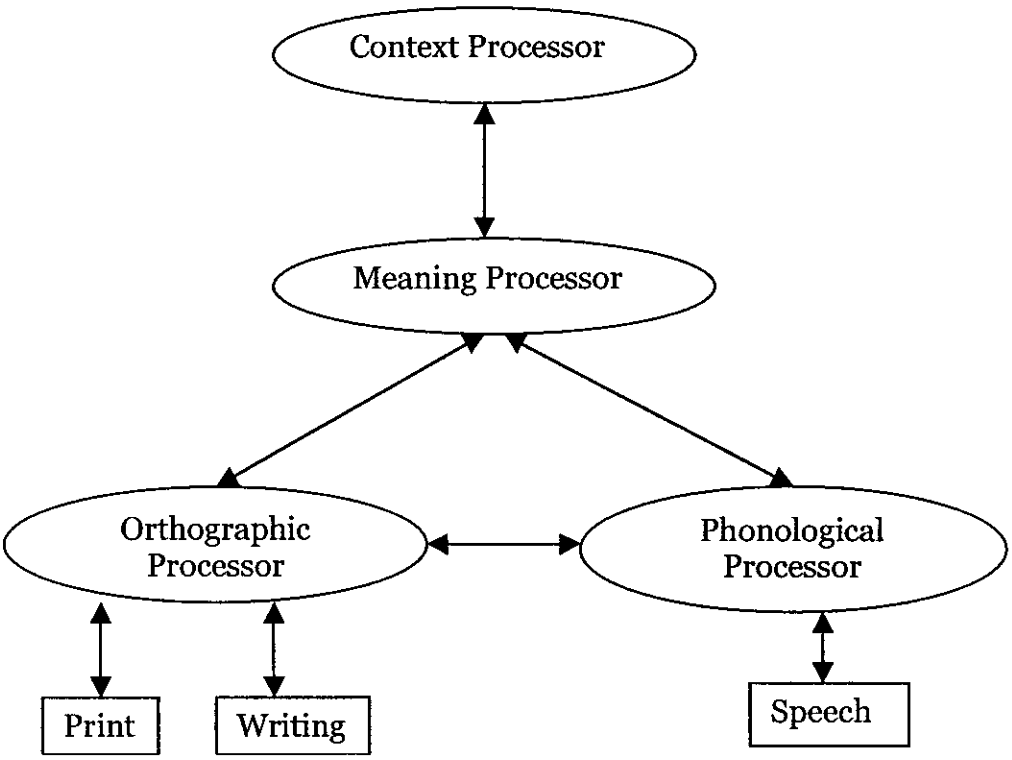

Figure 1 Adams' (1990) Model of Reading Acquisition.

The bottom-up or "code emphasis" theory advocates instruction at the orthographic and phonological level where phonological awareness establishes the alphabetic principle that facilitates the acquisition of reading and the derivation of meaning from text. Bottom-up theorists equip their students with tools to 'crack the code' of the alphabetic principle, enabling them to use a self teaching mechanism to decode known and novel words and obtain reading comprehension (Chall, 1979; Flesch, 1955; Share, 1995).

Adams' (1990) model of reading acquisition is partially illustrative of the interactive theory. The cognitive paradigm assumes that a single cognitive task is the product of a plethora of information-processing operations occurring either simultaneously or successively (Stanovich, 1986). In Adams' model this could be envisaged as spreading activation between all of the processors before a response (eg. reading, spelling, reading comprehension) is made. However, Adams' model does not fully specify all the information-processing operations that have been researched in reading. Stanovich (1986) includes in his interactive theory of reading the cognitive processes of phonological awareness, contextual processing, visual and speech perception, listening comprehension, general linguistic awareness abilities, and the effects of social background, motivation, self-esteem and short-term memory. The interaction between all these processes and perhaps others not yet isolated, establishes the possibility of compensations and reciprocal causal relationships between the different processes and the targeted responses. Stanovich postulates that there are limited resources available to the cognitive system and that the overall capacity of the cognitive system varies from individual to individual. Within an individual's cognitive system resources are allocated to the different information processes activated on any given cognitive task. If a cognitive process demands a high allocation of attentional resources then higher order processing will be thwarted to the extent that the limited capacity of the cognitive system is expended and depleted on lower order processes. Stanovich (1986) gives the example of word calling where students decode print without comprehension. One possible explanation is that students may allocate so much attention to the task of decoding that insufficient resource is available to allocate to comprehension, or students may have a deficiency in their comprehension processes and compensate by allocating more than usual attention to decoding.

Stanovich also postulates that different cognitive processes contribute different levels of activation to the overall cognitive task. Phonological awareness, for example, is resource demanding until an individual can automatically recognise a word and/or decode a novel word. Once decoding automaticity is established, phonological awareness ceases to make a contribution to word recognition (Gaskins, Gaskins, Anderson & Schommer, 1995). Similarly, once automaticity of word recognition is established there is a dramatic increase in exposure to print that facilitates vocabulary knowledge by ascertaining the meaning of words from their context. Stanovich (1986) postulates that a reciprocal causative effect occurs as word decoding becomes more proficient and as vocabulary knowledge increases due to an increase in print exposure. On the other hand, students who continue to have a deficit in decoding ability and/or phonological awareness do not reach this level of reciprocal causation between vocabulary knowledge and reading fluency and consequently, fall behind in the acquisition of reading ability (Stanovich, 1986).

Chew (1997) makes a distinction between new phonics and traditional phonics. New phonics is based on phonemic and/or phonological awareness. "Traditional phonics teachers", Chew maintains, "reject the suggestion that the ability to analyse spoken words into phonemes is a 'necessary precondition for a phonics approach'" (Chew, 1997, p.174). Read's (1975) precocious preschoolers and Morais, Bertelson, and Cary's (1986) illiterate adult Portuguese subjects have illustrated that phonemic awareness is a result of reading instruction and does not come with physical maturation. Traditional phonics does not seek to discover the sounds in words, but rather to teach orthographic and conventional spellings using letter names.

5. Summary of Reading Mechanisms

This research is located within the domain of phonological and phonemic awareness that have been isolated as significant predictors of reading and spelling acquisition (Adams, 1990) and through the Self Teaching Mechanism, enable children to decode novel words for themselves. The nonlexical and lexical reading mechanisms have also been shown to contribute to our understanding of the reading process. Consideration has further been given to the role of other cognitive processes that are activated and the different emphases that theorists place on their contributions.

Chapter Four PEDAGOGICAL FRAMEWORKS FOR READING

1. Historical Context

Traditionally, reading and spelling were taught using drill, repetition and rote memorisation (Ellis & Cataldo, 1990; Flesch, 1955). The inconsistencies and irregularities in the English writing system gave rise to the notion that spelling had to be learnt word by word and by rote visual memorisation from letter names (Treiman, 1993, 1997). Research indicated that words that had been rote memorised were soon forgotten (Taylor and Kidder, 1988) and that traditional methods of code instruction delayed the onset of reading (Beck and McCaslin, 1977). This research contributed to traditional phonics programs becoming increasingly unpopular.

Top-down theories of reading offer relief from the drudgery of the traditional approach to reading and spelling (for further information see page 31). The major contributions of the top-down theories include attention to the construction of meaning, motivation, child-centred instruction, the immediate integration of reading and writing, teacher empowerment and pre-eminently the cessation of phonics instruction in isolation from meaningful text (Stanovich, 1993). The disavowal by top-down adherents of the systematic teaching and learning of phonics remains the differentiating issue between the top-down and bottom-up theories (Stanovich, 1993).

The interactive theory of learning that seeks to combine both top-down and bottom-up processes, together with the development of phonological awareness and the alphabetic principle will now be traced.

2. Origins of Phonological Awareness and the New Phonics

Research performed by Bruce in the 1960s marked the origins of phonemic awareness (Bruce, 1964 cited in Chew, 1997; Goswami & Bryant, 1990). Bruce constructed the first phonemic awareness task. It involved the elision of a single consonantal onset (JAM-AM), or the deletion of one consonant from an onset (e.g. SNAIL-SAIL or STAND-SAND) or the deletion of one consonant from a coda (FORK-FOR). He tested 20 preschool students who obtained an average phoneme-deletion score of 6.75 from 30 items. He tested children between 5 and 9 years of age and only the 8 and 9 year olds scored reasonably (16.4 and 26.7 respectively). Bruce's research indicated:

1. that pre-readers find phonemic awareness difficult;

2. that phoneme deletion tasks are more difficult than traditional phonics;

3. that phonemic awareness precedes phonics instruction and

4. that an explicit awareness of phonemes precedes an ability to manipulate them (Bruce, 1964 cited in Chew, 1997; Goswami & Bryant, 1990).

3. Experiments in Reiteration

Research in Russia by Elkonin (1973) confirmed that the spoken word was fluid and not easily broken into sound units the size of phonemes. Elkonin devised a method of materialising the sound structure of words using plain counters that were to be placed in a grid of empty boxes to symbolise the abstract sound units. (For further information see page 3). Words were dissected at the syllable level and then through drawling and reiteration the pronunciation of the subsyllabic sound units were identified.

Elkonin researched fifteen pre-readers. The children were required to analyse approximately 40 words of varying difficulty into their constituent phonemes. One individual was able to analyse 5 words and five others were able to analyse 1 word. The results indicated that the children were unable to analyse words into component sounds even with verbal assistance.

The same children were then exposed to the same words, but were instructed to mark each sound with a counter on a sheet of paper. This provided the children with partial materialisation cues. After the initial training only four of the children were partially successful at this task and none could do it perfectly. Finally, the same children were exposed to the same stimulus material, but were provided with further aids to materialise the sound analysis. They were given a picture of a named object and were to place counters in a table of boxes to coincide with the sounds in the name. On this task the children obtained an 82% success rate.

Elkonin's research indicated that children require prior training in objectifying and materialising sounds to be able to analyse and mentally manipulate the sound structure of words into constituent sounds. When Elkonin wrote, "reading is not simply the successive calling of the names of the sounds one after the other," he indicated that reading requires the psycholinguistic processing of two disparate phenomena, the spoken word and the written language (Elkonin, 1973, p. 1578; see also Gill, 1992).

4. The Phonetic Module

Independent research at the Haskin laboratories has confirmed that phonological awareness is absent in preliterate children (Liberman, 1997). This observation has led

Liberman (1997) to propose an unconventional theory of speech in contradistinction to the pre-existing conventional theory of speech. These two theories will be discussed in turn.

I. The Conventional Theory of Speech

In the conventional theory, the constituent elements of speech are sounds. These sounds are essentially no different from other sounds and noises except that they are invested with phonetic significance by the auditory perceptual system that receives them. Speech is the production of sounds that are cognitively invested with phonemic content that the listener then decodes in the same way that a reader decodes print to attain comprehension. That is, the same biological and cognitive processes that generate nonlinguistic sounds and symbols also process speech and print. Humans communicate by combining discrete and invariant sounds to produce speech and their corresponding graphemes to produce a proliferation of words. The biological and cognitive processes are on a par and function naturally to encode and decode written and spoken expression. Consequently, children do not require instruction in phonological awareness but can learn to write in the same way that they learnt to speak (Liberman, 1997).

II. The Unconventional Theory of Speech

The unconventional theory of speech, on the other hand, considers speech to be madeup of coarticulatory gestures comprising phonetic material that is specifically generated for linguistic purposes. The auditory modality is also phonetically encoded. A primitive phonetic module that is unique to human beings, biologically determines the coarticulatory gestures of speech and hearing. Reading and writing on the other hand, are cultural inventions of human cognitive processes. To quote Liberman, "we were biologically destined to speak, not read or write" (Liberman, 1997, p.5). The productions and perceptions of the phonetic module that make human communication possible are not available for conscious inspection. Deliberate and conscious cognitive processes are necessary to parse coarticulatory gestures into their phonemic constituents and this does not come naturally. "The phonetic module", Liberman emphasises, "is independent of cognition and, indeed, of all other-than-linguistic modes of production and perception", but the clarity and quality of phonological representations aid the acquisition of phonological awareness and the alphabetic principle (Liberman, 1997, p. 16).

Liberman points out that the unconventional view of speech has been generative of the phonemic and phonological research whereas the conventional view of speech continues to foster traditional phonics and the top-down theory of reading that disregard this empirical evidence (Liberman, 1997; Stanovich & Stanovich, 1995). Research that has been based on the unconventional theory of speech and phonemic awareness will now be examined.

5. The Connection-Forming Process

The new phonics theory of learning has established empirical evidence that children can learn to manipulate the component sounds in words and can apply the alphabetic principle of mapping sounds with letters. Research by Ehri and Wilce (1985) added an extra dimension to this theory of reading that has become known as the "connection-forming process" (CFP). The CFP is the mechanism that fixes word knowledge in memory by a process of forming connections between orthographic and phonetic information so that the symbol-sound correspondences in words are fully analysed to achieve reading and spelling knowledge. Where rote visual memorisation has failed to equip children with an enduring method of retaining words the CFP has succeeded (Taylor & Kidder, 1988). The potential of the CFP to contribute to reading is another reason to maintain research in phonological and phonemic awareness.

How does the CFP work? Ehri and Wilce (1985) pretested and preselected three groups of 16 students; a group of prereaders who could not read any words, novices who could only read a few words and veterans who could read several words. The children were given two paired-associate learning tasks. The first task contained visually distinctive spellings where the letters did not correspond to sounds but were made to configure with familiar objects like a knee or a giraffe. The second task consisted of a set of letter name phonetic spellings of the same objects for example, NE for knee and JRF for giraffe. The prereaders responded more to the distinctively visual spellings, and the novices and veterans more to the phonetic cue information of the second task. Ehri and Wilce interpreted these observations as indicating that children shift from visual cues to phonetic cues. Children discover that visual cues convey insufficient information for reading and move to phonetic cues. When the phonetic cues for processing the sounds in a word's pronunciation are connected to the visual cues of the graphic form, learning takes place. Visual cues alone or visual cues linked to semantic information were insufficient to support subsequent word recognition and spelling in transfer tasks. Optimally, phonetic cues connect with visual cues and semantic information to enable learning and word recognition (Ehri, 1995, 1997; Ehri and Wilce, 1985,).

Ehri and Wilce (1987) conducted a training program on two groups of preschool children. The experimental group was taught to sound out and blend the letter-sound correspondences in several sets of mostly nonwords that had been fabricated from a small selection of consonants and long vowels. The control group were taught the letter-sound correspondences of 10 letters including both vowels and consonants. The children were given tiles to use in their responses. An analysis of the children's responses indicated that the experimental children could match spellings to pronunciations better than the control group. The research indicated that the experimental children made greater gains in phonetic cue processing and storing words in memory when the sounds in the words were connected to the letters in their spelling (Ehri and Wilce, 1987). This research confirmed the connection-forming process of word recognition.

To determine if CFP operates at the phonological (larger, coarse grain) or at the phonemic (smaller, fine grain) level, Ehri and Robbins (1992) performed research on four groups of elementary school children. Two groups of 19 students who could decode some words at pretest were designated decoders and another two groups of 20 students who could not decode were designated non-decoders. The training stimuli consisted of CVVC analogy and control words written in capital letters with a bar over the top of the vowels (e.g., analogy word, KAAV; control word, RAAN; transfer word, SAAV, and the vowels were capped with a single bar over them). The decoders who were taught the analogy words out-performed the decoders who were taught the control words in relation to the transfer words and both groups of decoders outperformed both groups of nondecoders. The nondecoders who were taught the analogy words, outperformed the nondecoders who were taught the control words in relation to the transfer words (Ehri & Robbins, 1992).

The fact that the children who were taught analogy words outperformed those taught control words seemed to indicate that a shared rime unit made reading the transfer words easier than identifying the letter-sound correspondence of the control words. Does this indicate that larger units are more critical than smaller units? Ehri and Robbins (1992) suggest that this research indicates that the larger units consisting of two segments (onset-rime) are only quantitatively easier to process than the smaller units consisting of three segments (onset-vowel-coda) and that these results do not indicate that phonological awareness is more effective than phonemic awareness on these tasks.

In the test trial the decoders were able to read the transfer words while the nondecoders were unable to read them, indicating that decoding is necessary for beginners to read novel words by analogy to known words. The decoders were those using a connection-forming process between the spelling of the words and their spoken pronunciations. The nondecoders were those using a connection between visual cues and their spoken pronunciations.

This research confirms that the connection-forming processes accompany decoding ability both at the phonemic and phonological levels. The acquisition of decoding and recoding ability facilitates and enables reading by analogy (Ehri & Robbins, 1992).

Ehri's (1995) four phases in the development of reading describe different levels of connection-forming processes linking symbolic information with spoken pronunciations to establish relationships stored in memory. In the prealphabetic stage beginners store selected visual attributes of words or familiar logos with their pronunciations. In the partial alphabetic stage children connect phonetic information in some letters (e.g. the first and/or final consonants) to their spoken pronunciations. In the full alphabetic phase constituent sounds in a word are completely and phonemically analysed and connected to their spoken pronunciation. Finally, in the consolidated alphabetic phase there is a complete bonding of the fully analysed spelling of the word with its full and automatic recognition and meaning (Ehri, 1995, Ehri, 1997).

Ehri has added a dynamic principle to the new phonics theory of reading to account for the effectiveness of its cognitive operations. The connection-forming processes ensure that learning takes place when conscious and deliberate efforts are made to shift through the developmental phases into literacy.

6. Reading by Analogy

The unconventional view of speech has proposed that words emanate from a biologically determined phonetic module in the form of coarticulated gestures (Liberman, 1997). These gestures are not open to cognitive analysis whereas communication in the form of print is culturally determined and open to cognitive processes. The sounds we associate with the letters in a word like BAG are /be/, /ah/, /geh/, but blending these sounds does not precisely represent the coarticulated gesture of the spoken word BAG. Some reading researchers propose that there is a progressive development from the syllable to the onset-rime unit to the phoneme level (Bryant and Bradly, 1985; Goswami and Bryant, 1990; Treiman, 1985). Research related to this progression will now be addressed.

I. Rhyming and Alliteration

Longitudinal studies that have taught children how to identify rhymes at the ends of words and alliteration at the beginning of words have indicated that phonological awareness in the form of recognising similar and dissimilar sound patterns facilitates and predicts reading acquisition (Bradley, 1987; Bryant & Bradley, 1985; Bryant, et al. 1990; Goswami & Bryant, 1990). (For further information see Chapter six 6:1)

II. Onset and Rime

Research by Treiman (1985) indicates that the internal structure of the syllable has an hierarchical organisation. The nature of this organisation is related to the bonds within the sublexical units constituting a syllable. The more natural units have the strongest bonds and resist segmentation more than other units. Research indicates that the division of a syllable into onset and rime units is more natural than a division within the more cohesive rime or onset units. (See the entry "Subsyllabic units" in the glossary for further details.)

In four experiments, Treiman (1948) involved 48 primary school students in a series of games and tasks to examine their responses to onsets, onset clusters, rimes and antibodies of consonant-vowel-consonant (CVC) or consonant-consonant-vowel (CCV) words. The results of Experiment 1 indicated that the rime unit is cohesive, and resists being forced to split and donate a vowel to an onset to form an antibody, and that onset clusters are cohesive and resist being forced to split and donate a consonant to the vowel to form a new antibody unit (Treiman, 1985). The results of Experiments 2 and 3 indicated that children could hear and perceive an initial consonant singleton (CV) more easily than an initial consonant cluster (CCV) showing that onsets are cohesive units. Finally, the results of Experiment 4 indicated that first grade children misread and have more difficulty reading the CCV nonwords than the second grade children.

Treiman concluded that the internal organisation of the syllable is hierarchical and that lower levels in the hierarchy require greater conscious attention than the higher levels. That is, breaking syllables into onset and rime units is easier than splitting onsets or rimes into phonemes (Goswami, 1995) because onsets and rimes are linguistic realities and are highly salient. Research by Goswami (1986, 1988 as cited in Goswami, 1993) has also illustrated that children can predict the pronunciation of novel words from their knowledge of other words that have similar spelling patterns (cited in Goswami & Bryant, 1990; Goswami, 1991; Goswami & Mead, 1992). More specifically, Goswami's research has indicated that children benefit more from analogies based on orthographically and phonologically identical rime spelling patterns like the /eak/ sound in peak and beak, than they do by analogies based on orthographically and phonologically identical antibodies like the /bea/ sound in bean and beak. However, learning words by analogy does not extend to orthographically similar words that are phonologically dissimilar for example, the /ost/ sound in most and cost, or phonologically similar but orthographically dissimilar like the /ed/ sound in head and said (Goswami & Bryant, 1990). This research therefore indicates that the contiguous presentation of phonologically and orthographically similar information is necessary in the development and use of analogical knowledge.

Goswami (1991) studied the responses of 20 infant children to onset clusters (e.g. the TR in trim: trap, trot) and to coda clusters (e.g. the NK in wink: tank, bunk). The results demonstrated an analogy affect for the onset units but not for the coda units, suggesting that the onset is a natural linguistic unit and that the coda is only a segment of a larger natural linguistic unit, the rime.

Her second experiment studied the responses of 30 first and second grade children to an antibody condition (e.g. trim-trip) and a rime condition (e.g. wink-pink). The effect on the rime condition was greater than the antibody condition that required the segmentation of this unit to form an analogy with the test material. This result supports the phonological hypothesis that the higher order linguistic units of the onset and rime enable the use of analogy reading strategies (Goswami, 1991).

III. The Phonemic Representation Hypothesis

Research by Treiman, Zukowski and Richmond-Welty (1993) on the spelling of coda clusters in CVCC nonwords has indicated that first grade children's spelling reflects the linguistic and phonological characteristics of those clusters. If the children perceived the final cluster as a single consonant (e.g., rl, nk) then they only represented it with the final consonant of the cluster (i.e., l, k).

Their research also indicated that vowels adhere to the postvocalic liquids (e.g., al, ir) or postvocalic nasals (e.g., an) forming inseparable consonantal or vowel units. That is, children phonologically represent CVCC nonwords as CVC nonwords in their phonemic analysis. Their omission of unperceived phonemes including postvocalic vowels or the initial consonant of a coda indicates that they are representing words phonemically and not operating from the traditional strategy of rote memorisation and orthographic knowledge. The conventional spelling of CVCC words by adults indicates that the precise phonemic representations are contained in their orthographic lexicons. This research agrees with the unconventional view of speech and its tenet that an individual's phonological representations are not open to conscious awareness. This lack of conscious access to phonological processes may act as a barrier to the acquisition of the alphabetic principle where phonemes are mapped to graphemes. Treiman et al's research also contributes to our knowledge of rimes and onsets forming natural linguistic units that are highly cohesive.

IV. The Interactive Analogy Model of Reading

The interactive analogy model of reading moves away from the developmental model where children move through logographic, prephonetic, phonetic and orthographic phases of reading (Chall, 1983; Goswami, 1993), to an interactive model where interaction between larger phonological and orthographic intrasyllabic units precedes interaction between fine grain phoneme-grapheme units (Cataldo and Ellis, 1988; Ellis, 1990; Goswami, 1993).

Several experiments were designed to demonstrate transfer between words with matching phonological-orthographic rime units and those with near matches where a consonant in the coda differed (Goswami, 1993). For example, if knowledge of the rime in PEAK could be shown to transfer to BEAK and not to HEAP, then larger than phonemic units were contributing to reading acquisition.

Experiment 1 studied the responses of 20 beginner readers to sets of rime words (clue word BUG: RUG, MUG); sets of antibodies (clue word BUG: BUD, BUS); and sets of vowel-only words (clue word BUG: CUP, GUM). The results indicated that the vowel-only stimuli and antibodies made virtually no contribution to transfer, whereas the rime units yielded significant levels of transfer. Experiment 2 studied infant school children's responses to sets of rime words (BEAK: PEAK, LEAK); sets of antibodies (BEAK: BEAN, BEAT); sets of vowel-only words (BEAK: HEAT, MEAN) and sets of common letter control words (BEAK: BANK, LAKE, BASK) and Experiment 3 added onset clusters to each of these sets of words. The results for both experiments indicated that rime and antibody transfer effects were significantly better than the vowel-only words and the common letter words (Goswami, 1993).

Goswami's research indicated that beginner readers can transfer from known to unknown words when the phonological and orthographical patterns are identical and contiguous in onset and rime units whereas infant readers can transfer learning from both rime and antibody units where there is contiguous information (Goswami, 1993).

Goswami attributes transfer effects to awareness of the psycholinguistic units of onset and rime but is unable to account for the transfer effects observed with antibody units. The current research will illustrate that it is the contiguous presentation of orthographical and phonological information that contributes to transfer effects and that grade 2 children transfer learning at the vowel-only level when the contiguous effects are compared to the presentation of variant orthographical and phonological information.

V. The Orthographic Rime Hypothesis

The orthographic rime hypothesis proposes that children use orthographic rimes as functional units in learning to read. Bowey and Hansen (1994) investigated 205 first grade children who were graded according to their reading age. In Experiments 1 and 2, the children were tested on pseudowords that consisted of common and regular orthographic rimes and uncommon but regular orthographic rimes. The significant results reflected a direct relationship between prior reading skill and the use of the orthographic rime frequency effect, where children read common pseudowords better than uncommon ones. These results parallelled Ehri and Robbins' (1992) observations where decoders were able to manipulate rime units better than nondecoders, indicating that a prior knowledge of decoding is essential for analogy reading strategies (Bowey & Hansen, 1994).

In two experiments, Bowey (1996) presented university students with consistent regular words (e.g., WISP, WELD). and atypically irregular ones (e.g. MONK, STEAK). (For information regarding these terms please see the glossary.) In the experimental task, orthographic rime primes facilitated the reading of the consistent regular words but not that of the atypically irregular ones. These results confirmed that the contiguous presentation of phonological and orthographic information primes the subsequent reading of words but variant phonological and/or orthographic information inhibits it.

In Experiment 3, Bowey (1996) presented university students with inconsistent typically regular words (e.g. LEAF, FROST, GOLF) and typically irregular words (e.g., GRIND, HALT, MAST) on rime prime tasks. The results indicated that "typically irregular words were intrinsically faster to name than inconsistent but typically regular words" (Bowey, 1996, p.124) and that a typically irregular orthographic rime prime like the /ind/ in GRIND facilitated the reading of other words in this rime family. The irregularity of the rime /ind/ did not interfere with or inhibit its ability to prime words in that rime family. This phenomenon is also known as the 'consistency effect' that occurs when words are typically consistent or inconsistent. If the phonological and orthographic information of these rime primes are identical to that of the rimes in the target words then the effect is facilitative but if it is variant it becomes inhibitive. The effects that either phonological variance or phono-orthographical contiguity can have on the processing of words is pertinent to the material used in the current research thesis.

Experiment 4 in this series by Bowey presented university students with consistent regular words and typically irregular words (e.g. GRIND, PALM). The results showed that "consistent regular words were named no faster than typically irregular target words" (Bowey, 1996, p. 126) and that the basis of phonological recoding rested on the consistency and contiguity of phono-orthographic information. That is, efficient word processing depends on the clear, unambiguous and contiguous connection between the written orthographic information and the spoken pronunciation of words.

A similar connection has also been observed in research on Chinese with pinyin that incorporates phonemic and tonal information in its characters. Research by Xu, Pollatsek, and Potter (1999) indicated that a distracter to a target in a Chinese word using pinyin orthography would not be activated to produce an erroneous pronunciation unless the consonant, vowel and especially the tone were all labelled contiguously.

The accumulated research of Ehri, Trieman, Goswami and Bowey and their colleagues has indicated that the contiguous presentation of phonological and orthographic information facilitates learning and processing in reading. This research confirms the unconventional theory of speech and that children require instruction in learning to decode print. Treiman, Goswami and Bowey have postulated that onsets and rimes are functional linguistic units relating phonological and orthographic information. However, this researcher suggests that although the onsets and rimes have been demonstrated to be cohesive linguistic realities their contribution to reading acquisition lies in the consistent and contiguous presentation of the grapheme-phoneme information contained in those units and not in the units themselves. This researcher suggests that it is the connection-forming processes that facilitate reading acquisition and that these processes are present whenever phono-orthographical information is presented contiguously, irrespective of the size of the subsyllabic unit.

7. The Rime: An Optimal Linguistic Unit

The primary goal of Treiman et al's (1995) analysis of a corpus of 1329 monomorphemic words was to ascertain the relative spelling-sound regularity of the antibody compared to the rime body. They statistically analysed the consonants, vowels, onsets, antibodies, rimes and codas of their chosen corpus of stimuli. The statistical analysis of these words confirmed that rime units have significantly more neighbours and consistent pronunciations than either antibodies or vowels. This indicates that the rime unit is more stable and predictable than the other linguistic units. The specific value of the rime lies in the consistency that is generated when the vowel and coda are combined (see also Greaney et al., 1997b). Antibodies have a greater variety of pronunciations than rimes. Consequently, there is less uncertainty in mapping sounds to rimes than to antibodies. Both in spoken and written language rimes produce a high degree of statistical redundancy. This redundancy contributes to an economical means of recognising spoken rime patterns and parsing words into onsets and rimes (see also research by Zinna, Liberman, & Shankweiler, 1986). A further analysis of the English language reveals that these rime bodies often form morphemic units that explain other consistent recurrences, for example, the alternation in pronunciation of the rime 'eal' in HEAL and HEALTH (Treiman, Mullennix, et al., 1995; Venezky, 1970).

Treiman, Mullennix, et al.(1995) also controlled their data for frequency, regularity, word length and consistency effects by using measures of word type and word token. (For further information concerning these concepts please refer to the glossary.) Additionally, the type and token measures were calculated for occurrences of the sublexial units of onset, antibody, vowel, rime and coda. The results of these analyses pertinent to the current research are that the control of frequency effects seems not to be essential, as the type and token measures accounted for similar percentages of variance in Treiman, Mullennix et al's chosen corpus of words.

Rastle and Coltheart's (1999b) research indicates that there is a left to right serial position effect of irregularity such that irregularities in the onset or vowel position are more likely to affect pronunciation than in the coda or rime. Rastle and Coltheart have surmised that word naming latency is dictated serial fine grain left to right process. Treiman, Mullennix, et al.'s (1995) research confirms that fine grain irregularities in the onset or vowel position do hurt performance more than irregularities in the coda, but further suggests that inconsistent rime pronunciations are relatively more detrimental to reading performance.

Treiman, Mullennix et al.(1995) also studied university students and second semester grade 1 children through to grade 5 children, their results confirmed that consistent rime patterns assist students in word naming more than consistent antibodies. For the children, inconsistent rimes produced more errors than consistent antibody words illustrating that this inconsistency was detrimental to their performance in word naming. Their research indicated that beginner readers rely on rime patterns and that this reliance is most evident at grade 2 and decreases until grade 5 when it approximates an adult pattern.

For the first time in the literature, Treiman, Mullennnix et al's research indicated that students' response latency to homophones is slower than for nonhomophones. Homophones contain variance between the orthographic and phonological information and therefore, present respondents with noncontiguous material (see also Boyle and Coltheart, 1996). This observation in particular contributes to the thesis that the contiguous presentation of ortho-phonological material enhances reading performance whereas the presentation of ortho-phonological variance hurts it.

Treiman, Mullennix et al.(1995) interpret their research as indicating that rime units reduce the variance between letter-sound correspondences and contribute to linking the spelling and sound components as in connection-forming processes. The capacity of the rime unit to reduce variance and contribute to the statistical regularities underlying English phonology and orthography has been demonstrated by Treiman, Mullennix et al. at a purely statistical level and by the responses of university students and primary grade children. The same measures also demonstrate that the antibody unit does not significantly contribute to a reduction in variance or the irregularities in the English script. Their research confirms that the contiguous presentation of ortho-phonological material is facilitative while variant presentations are prohibitive of literacy acquisition.

8. The Establishment of the Alphabetic Principle

In a series of five experiments, Byrne and Fielding-Barnsley (1989) researched the acquisition of the alphabetic principle by small groups of preliterate children. The children were selected on the basis of possessing no protoliteracy skills that is, they had no previous knowledge of letter names or letter sounds. The five experiments cumulatively examined the development of the students' ability to process the subskills necessary for the acquisition of the alphabetic principle. The children learnt by imitating a puppet's drawling segmentation of simple CVC words (e.g., MAT) into their onset and rime units. They were subsequently taught syllabic word reading using mnemonic devices to recognise for example, that DOORMAT contains the word MAT, whereas SITTING does not contain the word SAT. These two skills were taught to criterion before a transfer task was administered. At this stage of the training, the children could not transfer their learning to similar novel words indicating that they had not yet grasped the alphabetic principle. The children were next taught to segment and to identify identical onsets for example, that the words MILK, MOUTH, and MUM all began with the same letter-sound. The subsequent transfer test indicated that the alphabetic principle had still not been acquired. The children were then explicitly taught letter-sound correspondences using colour and shape coding, for example, the 'm' in a blue circle made the /*m*/ sound in MAT or 's' in a red triangle made the /s/ sound in SAT. The acquisition of the alphabetic principle was evident in the transfer tasks at this point in the training. Byrne and Fielding-Barnsley interpreted their results as indicating that children require direct and explicit training in segmentation and letter-sound correspondences for the acquisition of the alphabetic principle. The development of this training regime indicates that onset and rime knowledge by itself does not produce transfer whereas the training with the contiguous presentation grapheme-phoneme, phonological and morphemic training does.

Further research by Byrne and Fielding-Barnsley and colleagues (1991, 1993, 2000) has also confirmed that the contiguous connection between orthographic and phonological information is necessary for the acquisition of the alphabetic principle. That is, the alphabetic principle is established through an ability to segment the speech stream, and to recognise phoneme invariance in whatever position the same letter-sound combination occurs, for example, the /s/ sound in SAT and BUS (Byrne and Fielding-Barnsley, 1989; Byrne, 1993; Byrne, Fielding-Barnsley & Ashley, 1996). Byrne and Fielding-Barnsley's research has become a longitudinal study that has followed the literacy development of originally 64 experimental and 63 control children from preschool to grade 5. In preschool the experimental children were trained in the awareness of six consonantal phonemes. The children were taught to identify the selected phonemes using games, worksheets, posters and audio tapes. The experimental group was compared with a control group that also received training from the same teacher/researcher only the subject matter of their instruction consisted of classifying items either formally or semantically for example according to colour, shape, animacy, edibility, etc. (Byrne, Fielding-Barnsley and Ashley, 2000). After the training the experimental group outperformed the control group on measures of phonemic awareness and knowledge of the alphabetic principle (Byrne and Fielding Barnsley 1991, 1993). It was also found from the pattern of results that segmentation and phonemic awareness skills were necessary but not sufficient for a complete acquisition of the alphabetic principle. Evidently, some other unidentified developmental process or processes were contributing to its acquisition (Byrne and Fielding Barnsley 1989, 1991). At the end of preschool the research indicated that the experimental group outperformed the control group on measures of pseudo-word decoding. When tested in first and second grades the experimental group continued to outperform the control group in pseudoword decoding and reading comprehension (Bryne, Fielding-Barnsley and Ashley, 2000). By third grade the experimental group continued to outperform the third grade control group in pseudoword reading and in fifth grade the experimental group outperformed the control group in tests of reading irregular words, nonwords, and regular words and irregular words (Bryne, Fielding-Barnsley and Ashley, 2000). Byrne interpreted these results as indicating that explicit instruction is necessary for the acquisition of reading. Some children develop procedural knowledge at a preconscious level that enables them to achieve some levels of reading but through instruction children develop declarative knowledge that enables them to consciously analyse and know how to decode words when reading. This 'know how' is still evident in the responses of the experimental children after five years of schooling (Byrne, 1991, 1992; Byrne, Fielding-Barnsley & Ashley, 1996; see also Foorman, Fletcher, Francis, Schatschneider & Mehta, 1998).

Byrne (1996) further studied phonemic invariance and discovered that morphological and semantic processes influence the acquisition of the alphabetic principle. His research indicated that children could generalise phoneme invariance from the morphological relationship of the letter-sound /s/ between HAT and HATS to BIKE and BIKES, but not to the phonological function of BUG and BUS. Furthermore, children could generalise from HAT and HATS to DOG and DOGS where the semantic plural /s/ phoneme has a /z/ sound indicating that the morphemic value of the generalisation is occurring irrespective of the phonemic value. The length of the word did not contribute to the generalisation from HAT and HATS to BOOK and BOOKS. When the morphemic value of the added phoneme /s/ was withdrawn, like in the pair of words PURR and PURSE, generalisation did not reach criterion.

The same pattern of results occurred with the morphophonemic suffix /er/. Generalisation occurred with morphemically related GREEN and GREENER but not with the morphemically unrelated CORN and CORNER. Byrne interpreted this research as indicating that preliterate children were more orientated toward semantics than phonology. Morphological/semantic units are coarser grained than phonological ones. A morphological and semantic orientation to reading therefore contributes to a delay in the development of phonological and phonemic awareness and segmentation, and consequently the acquisition of the alphabetic principle (Byrne, 1996). Reading requires children performing the unnatural act of giving up reading for meaning and learning that print primarily maps to sounds (Byrne, Fielding-Barnsley and Ashley, 1997). Given that the sound structure of words is more like a stream than a row of buckets and is better characterised by a phonetic gesture than the succession of constituent sounds, phonemic segmentation is a culturally transmitted skill that often requires direct instruction (Byrne, 1996; Byrne, Fielding-Barnsley, Ashley and Larsen, 1997; Liberman, 1993).

The research by Byrne and his colleagues initially indicated that phonemic segmentation skill and phonemic awareness were necessary but not sufficient for the acquisition of the alphabetic principle. Some further factor was interacting with phonemic segmentation and phonemic awareness in reading acquisition. Their recent research indicates that children are orientated to meaning rather than the sound structure of words. Children therefore need to be given a reason to redirect their focus from the morphemic and semantic content of words to their phonemic structure. Byrne and his colleagues interpret their research as indicating that a movement from a morphemic/semantic analysis of the structure of words to a phonemic one is necessitated by the alphabetic nature of print (For more information see the glossary.) That is, a morphological analysis of print must be replaced with a phonological analysis because print primarily maps to sounds and not to meaning (Byrne, 1996). They also argue that irregular words contain some invariant letter-sound relationships that require phonological knowledge as well as some irregular letter-sound relationships that require word specific orthographic knowledge (Byrne, et al. 1997). This research confirms that invariant or contiguous letter-sound correspondences perform an integral function in reading acquisition.

A longitudinal study by Lundberg, Frost and Petersen (1988) confirms the findings of Byrne and his colleagues. Lundberg et al. administered daily training sessions to 235 Danish preschool children. The effects of this training were compared with a control group of 155 children. The effects of the phoneme awareness training translated into a higher performance by the experimental group in reading and spelling. Lundberg et al. interpret their results as indicating that explicit instruction in phonemic awareness develops the necessary metalinguistic skills for the acquisition of reading and spelling (Lundberg, et al., 1988: Lundberg, 1987).

9. Segmentation, Not Rime First

Yopp (1988) researched 94 kindergarten children on a battery of phonemic tests and performed a principal factor analysis on the results. The research indicated that four tasks of phoneme analysis loaded onto the first factor. Yopp called this factor "simple phonemic awareness" because it required children performing manipulations on the constituent sounds in the test items. The second factor called "compound phonemic awareness" required the children to hold information in short-term memory while they performed manipulations on the constituent sounds in the test items. The third factor called "rhyme only" required the subjects to identify if a word had the same end sound as a stimulus item and the fourth factor was called "auditory discrimination". This research is important for differentiating the phonemic awareness skills (factors one and two) from the phonological awareness skill of rhyming, although this skill is different from the ability to identify alliteration and rhyme used by Bryant and Bradly (1985).

Research by Stanovich, Cunningham and Cramer (1984) on fifty-eight kindergarten children indicated that children's ability to provide words that rhymed with a stimulus word or choose one of three words that rhymed with a stimulus item formed a separate factor to a further seven tasks that tested children's phonemic awareness. These rhyme tasks also varied from Bryant and Bradley's (1985) use of rhyme and alliteration to teach children how to become aware of the constituent sounds in words. However, Stanovich et al., Yopp and Bryant and Bradley all agree that phonemic awareness is a predictor of reading and spelling acquisition.

Hoien, Lundberg, Stanovich and Bjaalid (1995) investigated the contribution of phonemic awareness and rhyme to reading. They studied a sample of 128 preschool children and another sample of 1509 first grade children and analysed the data using a principal component analysis. The rhyme task involved the children matching one of three pictures to an object that rhymed with a stimulus word. The other tasks involved the children in syllable counting and phonemic awareness tasks that required the children to manipulate the sounds in words. The results indicated the emergence of a syllable factor, a phonemic factor and a rhyme factor. Hoien et al.(1995) and Snowling (1995) interpreted these results as indicating that phonemic awareness accounts for most of the variance in the acquisition of the alphabetic principle.

Muter, Hulme, Snowling, and Taylor (1997/8) further researched the role of rhyme and phonemic awareness using path analysis. Their results indicated that segmentation rather than rhyming was a stronger predictor of early reading and spelling attainment. This longitudinal study followed 38 prereaders till the end of second class. Segmentation was found to account for most of the variance related to the acquisition of reading and spelling, though rhyme made an independent contribution to the acquisition of spelling at the second grade level.

Further research by Nation and Hulme (1997) on 75 children from years 1, 3 and 4 indicated that phonemic segmentation rather than onset and rime segmentation was a better predictor of reading and spelling skill. In this study a robot taught children phonemic segmentation and onset/rime segmentation using Elkonin-like coins. The children were also taught the rhyme and alliteration sound categorisation tasks used in Bryant and Bradley's (1985) study. The application of hierarchical regression analyses to the data indicated that phonemic segmentation accounted for more variance than rhyme categorisation or alliteration categorisation or onset/rime segmentation. The contribution of rhyme and alliteration categorisation tended to indicate that children attended to the global sound structure of words (Nation and Hulme, 1997).

Bryant (1998) reanalysed Muter et al's (1998) data regrouping the rhyme detection data with the onset and rime data. The result of the reanalysis indicated that both phoneme awareness and onset/rime awareness contributed to reading and spelling acquisition variance. Hulme, Muter and Snowling (1998) disagreed with Bryant's interpretation of their data and claimed that phonemic awareness formed a stronger link between sounds and graphemes than onset/rime units, and that onset/rime units only contributed to a global sense of the sound structure of words.

Seymour, Duncan and Bolik (1999) reported on a study carried out with preschool children on two different tasks. The first was an odd-word-out task and the second was a common unit task. There were five sorts of word pairs; onset, body, peak, coda and rime. There were two versions of the shared onset, the simple version (FACE-FOOD), and the complex version (BREAD-BRUSH). This pattern was repeated for the coda (simple: WEEK-BAKE; complex: PAINT-COUNT), for the antibody (simple: MAT-MAN; complex: CLOTH-CLOCK) and for the rime (simple: BOAT-GOAT: complex: PASTE-WASTE). The results indicated that children could identify rhyme in the odd-word-out task but were then unable to identify rime units in the common unit task. Furthermore, children could identify simple onsets and codas in the common unit task but not the larger units of rime and body. Seymour et al's research indicates that contrary to Goswami and Bryant's (1990), Goswami's (1993) and Treiman, Mullennix et al's (1995) research the hierarchical development of phonological awareness starts at the fine grain level of simple onsets and simple codas, and then moves to the complex onsets and complex codas before attaining to the coarse grain level of the larger units of rimes and anti-bodies. Seymour et al. interpret this anomaly reversal of developmental trends to the difference between epi- and meta-linguistic abilities. Epi-linguistic awareness does not contribute to the conscious manipulation of sound units whereas metalinguistic awareness is. Epilinguistic awareness is more global and is characteristic of phonological awareness and the sound categorisation tasks of alliteration and rhyme, whereas metalinguistic awareness is more specific and characteristic of phoneme awareness and the manipulation of the constituent sounds of words.

Coltheart, V and Leahy (1996) studied the influence of rime bodies on the pronunciation of nonwords that were constructed by analogy to consistent, medium inconsistent and inconsistent words with grade 1, 3, and 5 children and adults. The results indicated that all groups based their pronunciations on grapheme-phoneme relationships more than on rime bodies. Children from the end of grade 1 applied grapheme-phoneme rules and children from the end of grade 2 until adulthood incrementally increased their use of rime body analogies to pronounce words. Bowey and Hanson's (1994) research also indicated that rime body effects only become noticeable from Grade 2 onwards and this is in keeping with the selection of grade 2 students in the present research.

Collectively, this research indicates that phonemic awareness that relies on the segmentation of phonemes from the speech stream precedes the segmentation of the phonological units of onset and rime.

The research by Yopp (1988), Lundberg et al. (1988), Seymour et al. (1999), Coltheart, V and Leahy (1996) and Muter et al. (1998), indicates that the metalinguistic skill of phonemic awareness is a more powerful predictor of reading and spelling acquisition than the more global and epilinguistic effects of phonological awareness. The present research has focussed on a phonemic presentation of grapheme-phoneme correspondences. The determination that phonemic awareness forms a stronger letter-sound linkage than phonological awareness still leaves unresearched a comparison of the contiguous and variant presentation of phono-orthographical information.

10. Summary of Phonological Awareness and New Phonics

This researcher considers the apparent conflict between research indicating the primary role of phonological awareness and research indicating the primary role of phonemic awareness could be reconciled by attributing the learning factor to the effects of contiguity. The development of new phonics can be traced to a conflict between the biologically determined phonetic module and the culturally determined script of written language. The research at both the phonological and phonemic levels indicates that the contiguous presentation of biologically determined phonetic information along with the culturally determined orthographic information leads to the acquisition of reading and spelling skills. Research indicates that the presentation of either phonological variance or orthographic variance is harmful to reading and spelling performance. This literature review would support and anticipate that the contiguous presentation of phonological and orthographic information leads to an enhancement of literacy development.

Chapter Five PSYCHOMETRIC FRAMEWORKS FOR READING

The previous chapter examined the pedagogical hypotheses regarding the acquisition of reading. The pedagogical research indicated that the contiguous presentation of grapho-phonological information benefited reading performance whereas phonological and orthographical variance was detrimental to reading performance.

The psychometric paradigms for reading acquisition will now be examined to evaluate whether a phonological or an orthographical route, or a combination of these, or a single route to reading best accounts for the available human and computational data.

The Dual Route Cascaded Model and the Connectionist models are theoretical frameworks that can be falsified by empirical data. Computational models are computer programs that are designed to imitate human reading processes. They provide a clearer description of the components and principles of the cognitive domain than verbal descriptions, and box and arrow diagrams (Bowey, 1996; Coltheart et al., 1996). The Dual Route and Connectionist theories generate models to perform computations that are thought to represent the cognitive and neurological processes of human behaviour. The more complete and sufficient the computational model the more accurately the model will simulate the empirical data. A model aims to be fully specified and make explicit all the cognitive functions and processes that characterise human performance. The models are continually being reformulated to attain full specification of reading mechanisms (Coltheart et al., 1999; Coltheart, et al., 2001).

The two dominant conceptual frameworks of reading are the Dual Route Models and the Connectionist models. The cognitive processes pertaining to the variant forms of the Dual Route Model propounded by Coltheart (1978) and his colleagues and variant forms of the Connectionist model propounded by Seidenberg and McClelland (1989) and their colleagues will now be analysed.

1. The Dual Route and Connectionist Models.

I. The Dual Route Model

Baron and Strawson (1976) are the original propounders of the Dual Route model. Their research indicated that some children, the 'Phoenicians', preferred to read using a nonlexical or phonological route from orthography to phonology[1]. On the other hand, children who prefer a lexical retrieval process are called 'Chinese readers'. In the Dual route model the lexical and nonlexical routes are dissociated from each other. The Dual route model also contains a de facto semantic route that is dissociated from the other two routes (Coltheart et al., 1993). In the Dual Route cascaded model (Coltheart, Rastle, Perry, Langdon, and Ziegler, 2001) reference is made to three routes; the lexical nonsemantic route, the GPC (nonlexical route) and the lexical semantic route that is awaiting implementation in a future computational model.

The architecture of the DRC model (see figure 3) illustrates the lexical and nonlexical routes. Coltheart et al. (1993) clearly state that each element of the model is a separate module and that the normal development of each module is a prerequisite for reading. Activation passes between modules by a cascaded process of immediate excitation or inhibition to other modules rather than the accumulation of excitation or inhibition reaching a threshold in a given module before being transmitted to other modules.

In the cascaded model activity in both the lexical and the nonlexical routes is initiated by activation at the letter level and each route immediately begins sending frequency-modulated feedback to the other route (Coltheart et al., 2001). The nonlexical route processes letters to form graphemes and the graphemes are converted to phonemes. The lexical route converts letters to words by a process of word recognition and word pronunciation. The nonlexical route in the computational Dual Route Cascaded (DRC) Model learnt the rules of translating letter strings to phonemes in a corpus of 2,897 monomorphemic and monosyllabic words selected by Seidenberg and McClelland (1989) for their connectionist computational model (see page 62). In English no phoneme consists of more than four letters where a grapheme represents a phoneme. The model automatically learnt the grapheme-phoneme conversion (GPC) rules that were not pre-specified by the computational script. The model successfully simulated regularity and frequency effects by the effective processing of GPC rules on regular words, but the model proposed that a lateral inhibition process was needed to prevent the regularisation of exception words by providing specific word processing, for example, to inhibit pint from rhyming with *mint*.

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[1] Baron and Strawson (1976) refer to the indirect non lexical phonological assembly route to reading as the "orthographic mechanism". The lexical route they refer to as the "phonological mechanism".

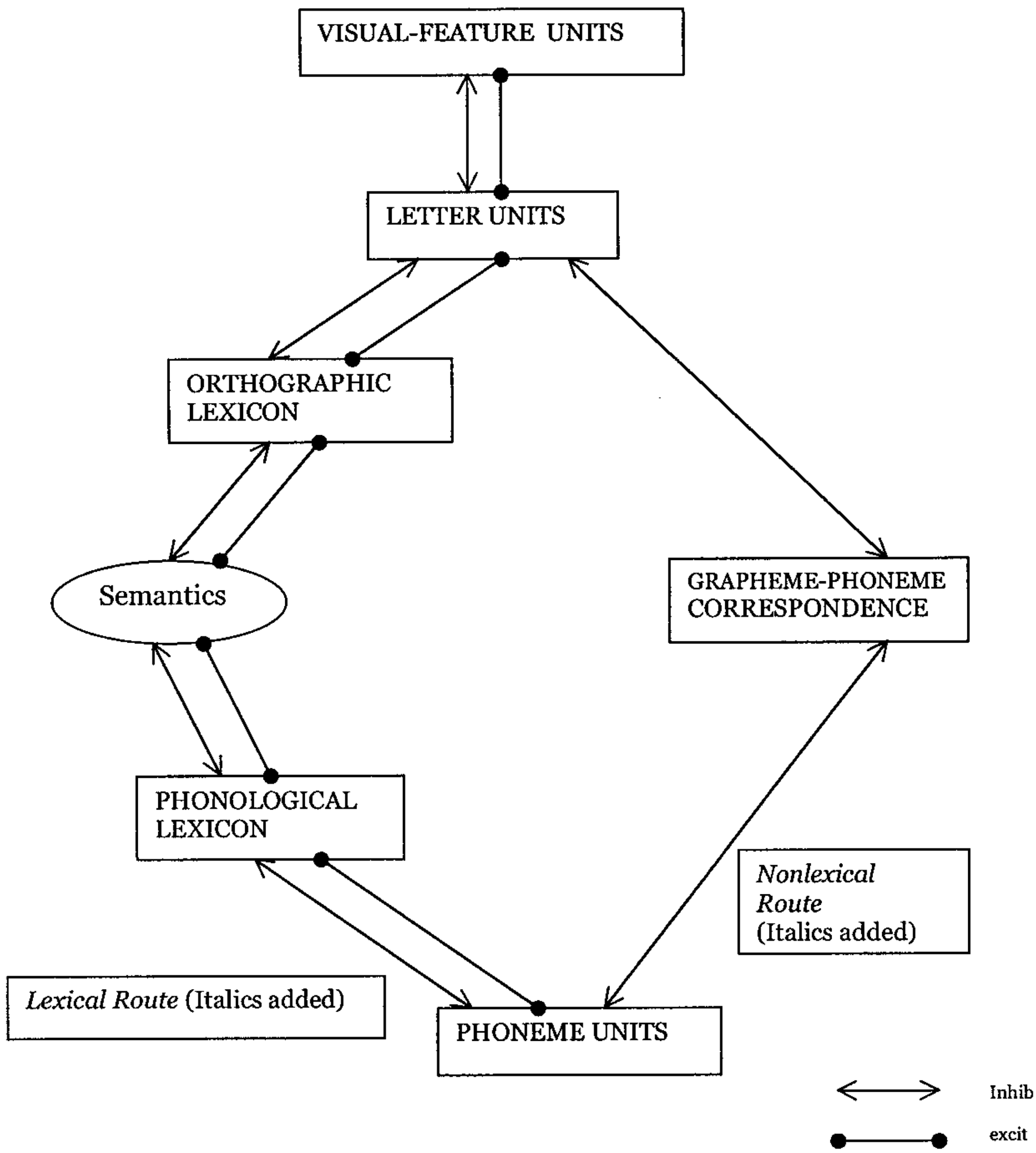

Figure 2 General Architecture of the DRC Model Coltheart, Langdon and Haller (1996).

The model learnt context sensitive rules whereby the pronunciation of a consonant depends on a preceding or subsequent letter. For example, the letter c changes to an /s/ sound when it is followed by the letters *"e"*, *"i"* and *"y"*, and the letter u changes to a /w/ sound when it is preceded by the letter *q*. The model also learnt specific position rules relating to letters or groups of letters in a word. That is, a phoneme corresponding to a letter may vary according to the position of that letter at the beginning, middle or end of a word (e.g., initial position *y* as in *yet*, medial position *y* as in *gym*, and final position *y* as in *sky*, where *y* in each position has a different sound).

The model learnt how to make the number of sounds in a word correspond to the number of letters. If the number of sounds was equivalent to the number of letters as in the word mint then the model applied a single-letter rule to learn the letter-sound correspondences. If the number of sounds was less than the number of letters then the model learnt to analyse the cluster of letters that represented phonemes and applied multi-letter rules until the number of phonemes corresponded with the number of graphemes in the word. For example, the word *blight* has four sounds but six letters. The model learnt that three of the sounds in the word have the regular letter-sound correspondences of *b, l & t*, it then attributed the remaining sound, the long /i/, to the remaining grapheme *igh*. The only instance where the number of sounds exceeds the number of letters is when the letter x is used (x represents the two sounds /k/ and /s/). (see Appendix B) The application of the model to the corpus of words translated 78.17% of the words correctly. The remaining 21.83% were exception or irregular words according to this model. The Dual Route Cascaded (DRC) model differs from the Connectionist model in that it allows frequently occurring patterns of words to remain irregular. For example, the words *shall, doll, wind (air), spook* and *plow* are atypically regular words whereas *small, roll, find, look* and *snow* are typically irregular and therefore regularised by the DRC model. Research by Patterson and Morton (1985 as cited in Coltheart et al., 1993) indicated that 93% of students decode nonwords with typically irregular rime bodies like *jook* to rhyme with the atypically regular word spook rather than the typically irregular *look*. An acquired dyslexic MP studied by Behrmann and Bub (1992 as cited in Coltheart et al., 1993) also regularised the spelling of *cook, crook* and *hook* to rhyme with *spook*. Coltheart et al., (1999, 2001) have subsequently added a lexical route to the DRC (1993) model and the updated model does simulate consistency effects. This is attributed to the cascaded activation of both routes and the neighbourhood *N* effect (Coltheart et al., 2001).

The spelling patterns of typically irregular words like *ask* and *all* have contributed to the development of the Connectionist model that consists of a single route for reading nonwords, consistent and inconsistent words. The Dual Route Cascaded model maintains that there are two separate and distinct routes to reading and that the analogical affect of typically irregular words does not detract from their irregularity and their need to be read lexically by a word recognition cognitive process. Coltheart et al. (1993) also agree that members of a typically irregular rime family (like *spook*) will affect the pronunciation of other members of that rime family that are atypically regular (like *look, hook, etc*) because of the cascaded nature of the model, but that this will not significantly affect the pronunciation of nonwords that are by definition not represented in an individual's inner lexicon. Coltheart et al.concede that if a single route lexical model could consistently pronounce nonwords to rhyme with irregular words then this would deal a devastating blow to the DRC model.

Glushko (1979) researched words that belong to a rime family that has two different pronunciations for example, the rime family /ave/ has the regular pronunciation of /ave/ as in *gave* and the irregular pronunciation of /ave/ as in *have*. Glushko called words like *gave* and *have* inconsistent because not all members of the rime family were pronounced the same. The Dual Route model designates *gave* as a regular word due to its compliance with GPC rules, and *have* as an exception word that requires lexical processing for word recognition. Glushko's research indicated that the naming latency for inconsistent words is greater than that for consistent words. Research by Seidenberg, et al., (1984) indicated that low frequency words with inconsistent rime families have higher error rates and longer response latencies than regular words with consistent rime families. The research by Glushko and Seidenberg et al. has engendered a single route model of reading that is based on analogy and the conceptualisation of words as lying on a single continuum from consistent to inconsistent, rather than being distinctly and categorically regular or irregular.

The empirical finding that low frequency exception words have longer response latencies than low frequency regular ones has affected the Dual Route Cascaded model. The DRC model recodes regular words and nonwords using the slow frequency sensitive nonlexical route and invariably recodes high and low frequency exception words using the fast frequency insensitive lexical route. The DRC model explains the longer response latencies of low frequency exception words by a conflict created by the two routes competing to name the word. The conflict between the two routes is time consuming and increases the naming latency for low frequency exception words.

The DRC model will be discussed in the light of current empirical evidence describing reading behaviours. It is based on the neuropsychological premise that different cognitive modules have independent neurological analogues and/or lexicons in specific regions of the brain, it appeals to neurological observations of different subtypes of dyslexia to substantiate dissociations between phonological, orthographic and other cognitive processes and postulates that individuals have strategic control over their lexical and nonlexical routes. The DRC model is emphatic that the reading of print begins with the left to right serial processing of letters and that letters or graphemic units are the basis of reading and not larger coarse grain units. Each of these propositions has been challenged by research and some of the results of that research will be examined.

II. The Connectionist Model

The Connectionist model of reading is also referred to as a Parallel Distributed Processing model of visual word recognition and pronunciation (Seidenberg and McClelland, 1989 or SM89). The model is based on the neuropsychological theory that neural networks of parallel and distributed neurons are activated in both hemispheres of the central nervous system rather than in localised neural centres (Behrmann, et al., 1998; Patterson, as cited in Humphreys and Evett, 1985). Seidenberg and McClelland emphasise that this model of reading does not involve an inner lexicon but information is captured in learned weights held in the hidden units between the different processors.

The orthographic, phonological and semantic pools of units form a triangle that has given it the name the Triangle model (see Figure 3 below). The SM89 version of the Connectionist model postulates a single route mechanism and is consistent with the GRAIN network that operates on the following principles (Plaut, et al., 1996). GRAIN is an acronym for the computational principles of graded, random, adaptive, interactive and nonlinear. "Graded" means that activation gradually builds up over time. "Random" refers to the intrinsic stochastic variability of the letter units in a word for example, each letter in a word can activate other words with that same letter until all the words with each of the letters of the target word have been activated. In each cycle the model processes triplets of letters called "Wickelphones". An error correction process then eliminates words until a word with the least amount of error correction remains and then that word is named (Behrman et al., 1998). The so-called "adaptive" principle captures information in the learned weights of the hidden units and is calculated using the delta algorithm of learning that is essentially a classical conditioning law (Coltheart et al., 1999; Coltheart et al., 2001; Ellis & Schmidt, 1998; Zorzi et al., 1998a). The learning procedure adjusts the weights by a process known as back-propagation. The units represent cycles of training of the model and are analogous to the learning that readers experience when exposed to print. The training regime consists of a cycle of exposure to the corpus of 2,897 words that have been frequency encrypted so that each word is represented with the monotonic equivalence to its estimated frequency value in Kucera and Francis (1967 as cited in Seidenberg and McClelland, 1989). This enables the simulation of the developmental mastery of both high and low frequency words. There is an interactive flow of information bi-directionally between the codes to maintain mutual constraints and feedback to the orthographic inputs and feedforward to the phonological outputs. The model is nonlinear so that inputs make similar units more sensitive or insensitive or neutralised depending on the additive effect. These principles working together sum the statistical regularity of consistency and frequency by adding together the similar changes in weights that occur during training (Plaut, et al., 1996). Consistency reduces error scores and inconsistency increases them as similar words contribute activation to similar units that aggregate and asymptote to the point of phonological output. The ramifications of this model will be discussed later.

A second version of the Connectionist model was formulated by Plaut, McClelland, Seidenberg, and Patterson (1996) and is called PMSP1. This model functions on the same principles as the first version (SM89) with one significant alteration.

A consideration of the properties that the Connectionist networks endeavour to combine illustrates the differences between the models. These properties are:-

1. All the knowledge in the model should be captured in the connection weights between the codes.
2. The network should capture the important regularities that generalise to novel items.
3. The constituents of an item should be processed in parallel to facilitate fast processing.

SM89 fulfils properties 1 and 3 but at the expense of property 2. The use of Wickelphone triplets of letters allowed the fast parallel processing and knowledge to be captured in the weights, but it also contributed to dispersing of the regularities between the orthographic and phonological outputs. PMSP1 replaces the Wickelphone triplets with Venezky's (1970) grapheme to phoneme relational units (not letters or letter features) between the orthographic input and phonological output and phonotactic and graphotactic constraints to prevent the further dispersion of phonemes and graphemes. The replacements greatly enhance the model's capacity to capture the regularities in the corpus of words and to generalise to novel items, particularly nonwords. The principle of intrinsic variability (i.e., randomness) and interactivity however, are consequently compromised. The implications of the model will be further discussed later (Plaut et al., 1996).

The third version of a Connectionist model is an attractor model. This will be referred to as PMSP2. It restored intrinsic variability and interactivity to this group of connectionist models. The randomness and interactivity of SM89 is replaced with a deterministic function in PMSP1. In PMSP2 the deterministic architecture and function are replaced with a componential attractor architecture and function. In PMSP2 there is an interactivity of connections between input orthography, semantic units and output phonology. Weights are formed and learnt in multidimensional state space to form basins of attraction, and lexical or sublexical (componential) units interact and adapt to settle into the nearest basin. If the system is damaged the word may settle in an incorrect basin. Nonwords may also settle in lexical basins producing lexicalization errors. The learning algorithm is also different. The training regime is called a "recurrent network" and is also known as "back-propagation through time". This allows feedforward and feedback propagation through time to compute error and adjust weights. The recurrent networking can occur at any time, past or present, to any unit and form arbitrary connections. The error propagated can be either from the internal structure of the model or injected into the network. The semantic contribution to the simulation is injected into the processing of the model. Another feature of PMSP2 is that the input orthography is not frequency coded but is trained using a global learning rate (Plaut et al., 1996). The results of this model will be discussed later in the context of the other Connectionist models.

Seidenberg's intention is to produce a model consisting of a single mechanism that is data driven and can give an account of the cumulative empirical evidence related to reading acquisition (Humphreys and Evett, 1985). The Dual Route model has two mechanisms, the lexical route that operates purely at the whole word level and the nonlexical route that is restricted to operating at the sublexical level of letters and graphemes according to invariant rules. Conceptually, the Dual Route model relegates words into two discrete categories, regular or exception, and this overlooks the inherent inconsistencies in exception, regular inconsistent, strange, unique and ambiguous words. The Connectionist models, on the other hand, place words on a continuum from consistent to very inconsistent (Plaut et al., 1996). Consequently, the primary aim of the Connectionist models is to simulate in a computational model consistency x frequency interactions that resemble human performance on the consistency continuum.

The further ramifications of the Connectionist model will be discussed in the light of current research and empirical evidence in the remainder of this section. The neuropsychological tenet of the Connectionist model is that the cognitive information processes of reading are neurologically distributed in the central nervous system and not localised in specific regions of the brain. This model has an explanation for the behavioural data characteristic of the different subtypes of dyslexia. It emphatically views words as not falling into discrete categories but forming a continuum from consistent to inconsistent. This model is able to analyse words according to a variety of sublexical units in a parallel and distributed manner, and not serially letter by letter. It can simulate consistency x frequency interactions for words on both ends of the consistency continuum. Each of these propositions has been challenged by research and the results of that research will be examined.

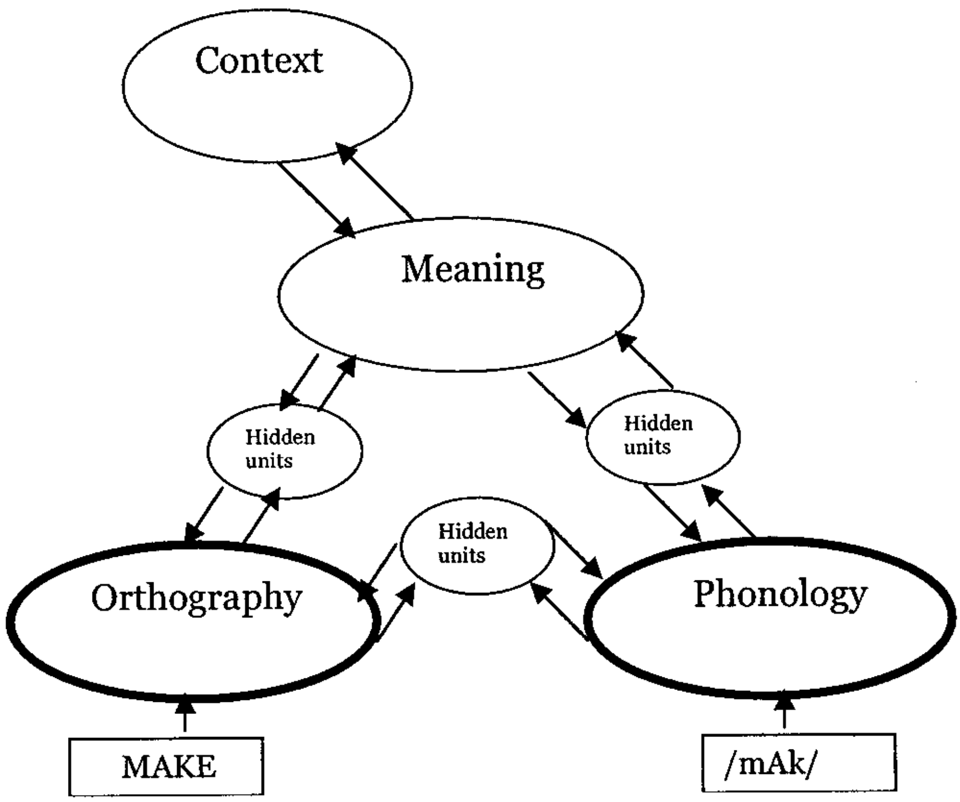

Figure 3 Seidenberg and McClelland's General Framework of a Connectionist Triangle Model of Lexical Processing.

2. The Phonological and the Orthographic Routes

I. The Neurological Evidence.

The dual route model endorses the localisation of anatomical centres in the brain that correspond to psychological functions. Coltheart et al. (1999) acknowledge the nineteenth century cognitive neuropsychologists Wernicke and Lichtheim who identified the location of functional linguistic modules in the brain (Coltheart et al., 1999, 2001). Fulbright et al. (1997) acknowledge the work of a mid eighteenth century neuropsychologist by the name of Gall who localised mental, motor and sensory functions in the cerebral hemispheres. The mapping of cognitive functions to localised cerebral functions has become quite detailed since the end of the nineteenth century (Fulbright et al., 1997). Owing to the advent of behaviourism in the first half of the twentieth century the neuroanatomical localisation of cognitive functions went out of vogue. The work of Penfield in the 1950s, Broadbent (1958 as cited in Coltheart et al., 1999), Treisman (1961 as cited in Coltheart et al., 1999) and Marshall and Newcombe (1966,1973 as cited in Coltheart et al., 1999) have initiated a renaissance of neuropyschology and the mapping of cognitive functions to localised functional modules in specific regions of the brain.

Fulbright et al. (1997) reported on the nonevasive functional MR (fMR) imaging technique of mapping the cognitive processes involved in transcoding to localised brain functioning. The different tasks elicited different processes that could then be subjected to a subtraction methodology to isolate different transcoding and literacy processes including visuo-spatial, orthographic, phonologic and semantic cognitive functions (Fulbright et al., 1997 for further information see glossary on subtraction methodology). The results of Fulbright et al's study have been superseded by further research by many of the same researchers who have administered the same tasks and applied the same subtraction methodology to a sample of reading disabled (RD) students and non-impaired students (NI) (Pugh et al., 2000).

The salient results of this research indicated that the posterior region of the left hemisphere (LH) of the brain is the location of the temporo-parietal (dorsal) circuit that is associated with the nonlexical route that transcodes orthographic input to phonological output and then integrates this output with morphological and lexical-semantic information. The posterior region of the LH of the brain is also the location of the occipito-temporal (ventral) circuit that is associated with the lexical route that transcodes orthographic input to phonology by the retrieval of specific word knowledge and recognition processes. The activation of both the temporo-parietal (dorsal) and occipito-temporal (ventral) circuits is disrupted for RD readers.

The anterior circuit of the LH inferior frontal gyrus is associated with gestural articulation, the recoding of speech, and the pronunciation of words and nonwords.

The research also indicated that RD students compensated for these disruptions by increased reliance on the inferior frontal gyrus and RH circuits that are homologues of the LH posterior circuits. The RH posterior circuits are associated with semantic compensation for the disrupted transcoding of orthographic and phonological information. These circuits appeared to be biological signatures of the cognitive processes responsible for literacy acquisition, and reinforced the dual route model of localised inner mental lexicons that facilitate lexical and nonlexical routes to recoding orthographic information to speech (Fulbright et al., 1997).

Pugh et al. (2000) observe that the functional connectivity between the angular gyrus, occipital and temporal lobe sites is weaker for RD students than NI students. The temporo-parietal (dorsal) circuit that is the centre of phonological processing and transcoding appears to be the source of this dysfunction implying the primacy of a phonological core deficit and disqualifying the possibility of a global lesion that may support a connectionist interpretation.

The dual route model supports the localisation of inner lexicons in specific regions of the brain. The connectionist model is based on a neuron-like processing that is global and does not imply the specification of neural circuits to particular cognitive functions. This current neuro-psychological research partially supports the dual route model. The phonological centre located in the temporo-parietal (dorsal) circuit is more definitively supported than the lexical and semantic centres. This pattern of activity may partially support the connectionist model that emphasises a single route from print to speech with either disruption of the phonological route or semantic compensation accounting for the responses of children with varying forms of dyslexia.

II. Acquired Dyslexia (Trauma to the Brain)

Individuals with surface dyslexia have a specific impairment to the lexical route to reading and consequently have difficulty reading exception words and tend to regularise exception words. There are no pure examples of acquired surface dyslexia but there are extreme cases where individuals can only accurately read 47% of high frequency exception words (Coltheart et al., 1993) and Coltheart, Langdon, and Haller (1996) consider these extreme cases to be pure cases of acquired surface dyslexia. Plaut et al., (1996) challenge the DRC model with the strong prediction that "there can not be an (English-language) surface dyslexia patient who reads no exception words" (Plaut et al., 1996, p. 101). So far it would seem there are no instances where a patient is unable to read any exception words.

The DRC model can account for different forms of acquired surface dyslexia by simulating lesions in the different components of the DRC model. According to this model, acquired surface dyslexia selectively occurs between the letter level and phoneme level within the lexical route, otherwise the lesion would cause children with acquired surface dyslexia to be unable to read nonwords as well as exception words. The DRC model has been able to accommodate lesions in the model by adjusting and limiting the operating parameters of the lexical route to simulate the different patterns of performance of different individuals with acquired surface dyslexia (Coltheart et al., 1996).

The SM89 model attributes surface dyslexia to damage to the direct route from orthographic print to phonological output. Research by Manis et al., (1996) indicated that developmental surface dyslexia represents a developmental delay in reading acquisition and can be explained as a mild form of phonological dyslexia. Consequently, Seidenberg and McClelland (1989) simulated a lesion to the direct route in the SM89 model to imitate the performance of individuals with acquired surface dyslexia but the attempt failed. They then surmised that the characteristic behaviour of acquired dyslexia might be due to a combination of damage to the indirect route via semantics and the direct phonological route.

The PMSP2 model was developed to attempt to imitate acquired surface dyslexia. The model allowed for extra units to be externally injected into the training regime to imitate a lesion to the semantic route and prevent the direct route from learning exception words. The resultant simulation did imitate the performance of a person with acquired surface dyslexia (Coltheart et al., 1996; Plaut et al., 1996). However, Coltheart et al. (1996) disagree that the premorbid semantic capacities of individuals with acquired surface dyslexia are commensurate with the injection of interfering semantic units into the model and also question whether the designers of the PMSP2 model can fully simulate a semantic route without the external manipulation of their model. Plaut et al., alternatively proffer the explanation that surface dyslexia is the outcome of a lopsided development of the phonological route in combination with insufficient support from the semantic route to enable the acquisition of specific word knowledge.

Acquired phonological dyslexia occurs when the nonlexical route to reading is impaired by brain damage. Funnel (1983 as cited in Coltheart et al., 1993) reports an extreme case where the nonlexical route is completely destroyed and the individual can read exception words but not nonwords.

The PMSP1 model relies on damage "within phonology itself" in combination with a mild impairment to the semantic route to account for acquired phonological dyslexia (Plaut et al., 1996, p.103). The DRC model can simulate a lesion in the nonlexical phonological route to imitate the reading of regular and exception words without reading nonwords (Coltheart et al., 1993; Seidenberg & McClelland, 1989). Alternatively, Seidenberg and McClelland suggest children acquire specific word knowledge of regular and exception words but fail to learn and encode generalisation abilities that would enable them to read novel items like nonwords. Coltheart et al., (1996) cite cases of acquired phonological dyslexia where the individual appeared to have damage to both the nonlexical route and the semantic route, and consequently, reads directly from the orthographic lexicon to the phonological lexicon bypassing the semantic lexicon.

The DCR model is able to simulate acquired phonological dyslexia but the Connectionist models are unable to simulate these results and can only offer accounts of possible future simulations (Plaut et al., 1996).

III. Developmental Dyslexia

Developmental dyslexia occurs as individuals develop reading skills. Children with developmental surface dyslexia predominantly read using the nonlexical route and laboriously sound out words and produce regularisation of exception words. On the other hand, children with developmental phonological dyslexia predominantly read using the lexical route, guess at unknown words and have great difficulty reading nonwords. Research by Castles and Coltheart (1993; Castles, 1994; see also Castles and Holmes, 1996; Coltheart, M and Leahy, 1996) and by Manis et al. (1996 see also Joanisse, 2000) have isolated individuals who exemplify these profiles within specific confidence limits (for more information see Two Mechanisms p 25). Stanovich, Siegel, Gottardo, Chiappe, and Sidhu (1997) and Snowling, Bryant and Hulme (1996) point out that Castles and Coltheart's (1993) research lacked a reading-level match and therefore questioned the validity of their research. Manis et al. repeated the research providing a reading level match and still isolated instances of both dyslexic subtypes but interpreted the pattern of responses of the children with developmental surface dyslexia as being developmentally delayed as distinct from those with developmental phonological dyslexia as having a phonological core deficit.

The research by Castles and Coltheart, and Manis et al. has tested children on their cognitive processing of regular, exception and nonwords to differentiate those with surface and phonological forms of dyslexia. There are several other studies that have isolated subtypes of children with learning difficulties. They have used tests that have indicated other cognitive skills that could have contributed to reading disability. Lyon and Watson (1981 as cited in Lyon, 1985) studied 100 11 and 12 years old children with reading disabilities and a control group of 50 children with normal reading development. They administered auditory and visual tests. The research indicated six subtypes of learning difficulty. There is a group with global language and perceptual deficits, a group with a milder form of global language deficit, a group with phonological deficits that can read exception words correctly but have difficulty with regular words, a group with visual motor deficiencies that read recoded regular and exception words nonlexically, a group with global linguistic and phonological deficits, and a group with a normal diagnostic profile (Lyon, 1985).

Seymour's (1987, 1990) research also indicated a set of dyslexic subtypes whose neuropsychological profiles and responses contributed to the development of an information-processing model that confirms Coltheart et al.'s model. His model has a visual processor, a phonological processor and a semantic processor similar to Adams' model. His data indicated that some children have developmental phonological dyslexia where the modular pathway between the phonological processor, and visual and semantic processors is impaired and that some children have developmental morphemic (acquired) dyslexia where the modular pathway between the visual (orthographic), semantic and phonological processors is impaired. He also identified children with impairments in all of the processors and who demonstrated global reading disabilities (Seymour, 1990).

Seymour (1990) acknowledges the contribution that Ellis' (1990) research has made to the formulation of his model. Ellis and Large (1987) conducted a longitudinal study with 40 infant children. Their study compared IQ measures with a battery of 40 tests. The salient results indicated that children with a high IQ but with reading problems have a specific deficit in phonological segmentation, short-term memory and naming.

Coltheart et al. (1996) give an example of a lexical non-semantic form of dyslexia where the specific module that semantically relates spoken words with pictures has been damaged whereas other modules enabling fluent reading continue to function. This behaviour seems to indicate that lexical processes are separate and independent from semantic processes (Coltheart et al., 1996).

Collectively this neuropsychological research indicates that children can be impaired in a variety of cognitive modules and confirms that a deficit in phonological processing is prevalent among children with learning difficulties and/or dyslexia.

The PMSP1 and PMSP2 versions of the connectionist model are able to simulate the reading of exception words and nonwords at levels comparable to normal human performance but have been unable to account for abnormal behaviours of specific disabilities.

The DCR model is able to account for developmental surface dyslexia and developmental phonological dyslexia whereas the Connectionist models that are limited to one mechanism are unable to manipulate the "phonological and semantic division of labour" to the point of simulating these reading behaviours (Plaut et al., 1996, p.95). It would seem that the only model that can account for the reading aloud of exception words and nonwords, and the various subtypes of dyslexia is the DRC model. A model that lacks a plethora of modules that can locate a variety of specific reading dysfunctions is unable to account for the empirical evidence (Coltheart et al., 1996).

3. Statistical Independence of Phonological and Orthographic Routes

Stanovich and West (1989) administered 25 measures of reading subskills to 180 undergraduate students. One salient result indicated that the orthographic tasks accounted for a significant portion of unique and independent variance. Stanovich and West accepted Frith's (1980, 1985) interpretation that orthographic difficulties are due to a shallow and nonanalytic phonological processing of print where children rely on context to facilitate word recognition.

Research by Cunningham and Stanovich (1993) with a sample of 26 first grade children and 7 measures of phonological and orthographic processing and print exposure also indicated that phonological and orthographic processing account for separate, unique and independent variance. Cunningham and Stanovich postulate that environmental exposure to print may account for the orthographic variance whereas phonological processing deficits may be attributable to biological and inheritable factors (see also Barker, Torgesen and Wagner, 1992; Wagner and Barker, 1994).

The Colorado Learning Disabilities Centre researched 296 twins (mean age 11.1 years), either identical or fraternal twins on a battery of tests including orthographic and phonological skills (Olson, Forsberg & Wise, 1994). The phonological and orthographic factors were found to be distinct but highly correlated. Olson et al. interpret this pattern of results as indicating that the etiological developments of phonological and orthographic deficits may be different.

Stanovich and Siegel (1994) researched a sample of over 1500 children on a plethora of variables and one pertinent result was that "phonological and orthographic coding abilities are at least partially separable" (Stanovich and Siegel, 1994, p. 42). Similar research reported by Fletcher et al. (1997) indicated that children with dyslexia have either a global cognitive deficit or a phonological deficit. Their research studied 378 primary children on a battery of psychometric tests and the results indicated that most of the children with specific deficits were relatively weak on phonological awareness. Fletcher et al., agree with Stanovich that phonological processing deficits characterise the performance of children with reading difficulties rather than aptitude and/or IQ measures, and that children can be separated into those with a "garden variety" or global cognitive deficit and those with a specific phonological deficit (Stanovich, Cunningham, & Feeman, 1984; Stanovich, 1991a; Stanovich, 1991b).

This research by Fletcher et al. (1997), and Stanovich and Siegel (1994) tends to support the independence of the phonological and orthographic processes.

4. Effects Favouring the Dual Route Model

Evidence supporting the serial letter by letter and left to right processing of print; the independent automatic activation of phonological and orthographic processes; and strategic control effects where individuals select lexical or nonlexical routes to word recognition all favour the DRC model of reading acquisition. Research relating to these three factors will now be examined.

I. The Serial or Parallel Processing of Sublexical Units

Rastle and Coltheart (1998) researched the length of nonwords that maintained a constant number of letters but differed in the number of phonemes (e.g., FOOCE compared to FRULS) to ascertain if the nonlexical route processes the two types of nonwords differently. The results obtained from a sample of 23 university students indicated that the original letter-by-letter DRC model produced longer naming latencies for the words containing fewer graphemes, than the words containing more graphemes but the same number of letters. They termed this the "whammy effect". The conclusion they derived from this observation is that "the relevant variable controlling the length effect on reading aloud is the letter not the phoneme" (Rastle and Coltheart, 1998 p. 281). The ramifications and importance of the letter in contradistinction to the phoneme is that some computational models of reading only input phoneme size units and therefore are unable to account for the whammy effect (Coltheart et al., 2001).

Rastle and Coltheart (1999b) also researched the position of irregularity effect in exception words. The aim of the research was to ascertain if the serial left to right (from first to fifth) position of irregularity affected naming latencies. The results from both human and DCR data indicated a left to right serial effect of irregularity in the reading aloud of exception words.

Research by Rey, Ziegler and Jacobs (2000) compared words like BEACH that have a multi-letter grapheme in the second position with words like PLACE that have a multi-letter grapheme spread between the third and final position so that the whammy effect was predominantly in the fifth position. These results also indicated that the serial position of irregularity does produce longer response latencies and that there is a monotonic and linear relationship between position of irregularity and response latency.

Coltheart, Woollams, Kinoshita, and Perry (1999) researched the serial position effect using the Stroop design. The sample consisted of 24 university students and the results indicated that colour naming is faster when the word and colour share a phoneme and the size of the effect is larger when the initial letter of the stimulus is the same as the initial letter of the colour. Both human subjects and the DRC computational model obtained these results once again indicating that reading is serial and sensitive to position (see also Kinoshita, 2000).

The DRC model is able to simulate the empirical data related to the serial position effect whereas Connectionist models that operate on the parallel processing of print are unable to simulate this effect (Coltheart et al., 2000). The SM89 and PMSP versions of the Connectionist models fall into this category.

A more recent computational model by Zorzi et al., (1998a, 1998b) also implemented a parallel representation of orthographic units into their Two Layer Assembly (TLA) model. The TLA model has two pathways. The first pathway was constructed on insights taken from Treiman, Mullennix, et al. (1995) and Goswami and Bryant (1990) that onset and rime units capture the statistical regularities and frequencies of the English language, and facilitate reading acquisition. This pathway deterministically linked orthographic input with phonological output using a slot based, parallel and distributed representation of onset and rime units. The pathway quickly and efficiently learnt to read nonwords, regular, and consistent monosyllabic words and to regularise exception monosyllabic words. It acted as a nonlexical route to naming consistent words. The second, augmented or mediated pathway had hidden units that mediated the learning of exception words. The nonlexical and augmented pathways converged to read and name exception words. The nonlexical pathway was fast at assembling words whereas the mediated pathway was relatively slow at learning exception words. This is consistent with research that indicates that the phonological route to word pronunciation is fast (for further information see The Ubiquity of Phonology page 29 and page 74). The augmented pathway learnt to store specific word knowledge and the pronunciations of exception words. The build up of weights in the nodes that captured the information was gradual and involved excitation and inhibition. The model was able to reproduce frequency x regularity x consistency interactions. A lesion to the nonlexical pathway did simulate phonological dyslexia and the learning processes in the augmented pathway can be adjusted to inhibit the learning of exception words to simulate surface dyslexia without interfering with the semantic route.

Although the TLA model has two pathways it differs markedly from the DRC model. It does not implement rules, the assembly process is parallel and not serial, and the nonlexical pathway is quick whereas the case-specific augmented pathway is relatively slow. The nonlexical route generates regularity in the DRC model whereas the interaction between the nonlexical and augmented pathways generates regularity in the TLA model. Strategic control in the DRC model results from conflict and competition between the nonlexical and lexical routes whereas strategic control in the TLA model is a result of modulations within the processing of the two pathways. Furthermore the nonlexical and augmented pathways are considered to be neuropsychological analogues of neural networks (Zorzi et al., 1998a, 1998b) rather than localised anatomical centres in the brain.

Zorzi et al., have grounded their TLA model on the phonological awareness research of Bryant and Bradley (1985), Treiman, Mullennix, et al., (1995) and Goswami and Bryant (1990). This research supports the coarse grain units of onset/rime in preference to the fine grain units of single phonemes. Recent trends in research by Nation and Hulme (1997), Hulme et al., (1998), Seymour et al., (1999) and Coltheart. V and Leahy (1996) indicate that phonemic segmentation has re-emerged as the primal unit for recoding text (for further information see Segmentation, Not Rime First page 53) Further, Zorzi et al.'s model is overtly constructed on Parallel Distributed representations and are at variance with the serial position processing data of Rastle and Coltheart (1999b). The successful implementation of a computational model that purports to prescribe reading processes needs to account for all the empirical data that have been established by research. This includes the behavioural data relating to phonological and phonemic awareness as well as a plethora of other factors some of which have been mentioned so far and some which are still to be considered. Zorzi et al.'s TLA model is able to account for some of this data but insufficiently to compete with Coltheart et al.'s, (2000) Dual Route model.

II. The Ubiquity of Phonology and Orthography

Lukatela and Turvey's (1991) study of pseudohomophone primes indicated that the phonological representation generated by a pseudohomophone like TAYBLE in the presence of a target CHAIR produced naming latencies comparable to the associated words TABLE-CHAIR. Furthermore, a control prime like TARBLE did not produce the same effect whereas TAYBLE did prime CHAIR even with very short prime exposure times indicating that the phonological representation of TAYBLE was fast. Lukatela and Turvey interpreted these results as indicating that TAYBLE generates a fast lexical naming using a nonlexical route that by definition is unable to perform grapheme-phoneme conversions on nonwords even if they are pseudohomophones. Other research by Lukatela and Turvey (1990b as cited in Lukatela and Turvey, 1991) has indicated that lexical decision and naming tasks always imply the precedence of phonological processing over orthographic processing and that phonological access is automatic, fast and ubiquitous. Their research has indicated that phonologically similar priming effects are independent of graphemically similar effects for both lexical decisions and naming tasks. Coltheart et al. (2001) have reproduced the pseudohomophone effect in their Dual Route Cascaded (1999) model and the results have indicated that the lexical route contributes to the pronunciation of nonwords and that when the lexical route is disabled the pseudohomophone effect disappears. This is further evidence of the cascaded activation between the routes and modules of the DRC model and that although they can be dissociated they do not operate independently of each other.

Lukatela and Turvey (1993) had 36 university students name pseudohomophone primes (e.g., FOLE, HOAP) and their real word equivalent (FOAL, HOPE) at the same time as performing a memory load task. Naming latencies between the pseudohomophones and the real words did not differ significantly illustrating that nonwords are named by a fast nonlexical process. On the other hand, research with university students in France by Grainger and Ferrand (1994) compared orthographically similar homophone primes with orthographically dissimilar ones to show that orthographic similarity does significantly contribute to naming latencies. Grainger and Ferrand interpreted these results as indicating the fast and ubiquitous effects of orthographical/lexical processing.

Lukatela et al.'s (1998) research compared the prime effect of PLIP, CLEP and PREM on the word CLIP. PLIP has a similar phonological rime to CLIP and produced significantly better naming latencies than the orthographically similar CLEP or the control nonword PREM. Lukatela et al., cited these results as indicating that phonological similarity is more effective than orthographic similarity because CLEP is more orthographically similar to CLIP whereas PLIP is more phonologically similar to CLIP. The phonologically similar KLIP is shown to be the best prime for CLIP and illustrates that phonological similarity is of more consequence than orthographic similarity.

Ziegler and Jacobs (1995) studied the response latencies of German university students to pseudohomophones (e.g., BRANE) that phonologically relate to real words (e.g., BRAIN). The real word (BRAIN) contains a target letter "i" that is not present in the pseudohomophone (BRANE). The research compared the students response latencies to the pseudohomophones (BRANE) with their response latencies to control words (e.g., BRATE) that contained the same vowel sound but without the target letter "i". The response latency to reject the pseudohomophone (BRANE) as not containing the target letter "i" was longer than the response latency to reject BRATE for the same reason. The longer response latencies indicated that the real word BRAIN has ascribed and attributed the target letter "i" to the pseudohomophone BRANE and this behaviour is known as the "pseudohomophone disadvantage" effect. The pseudohomophone disadvantage effect indicates that the visual features of the pseudohomophone BRANE have automatically activated the real word BRAIN in the analogical phonological lexicon and activated the target letter "i" from the visual-orthographic features of the word BRAIN by the visual-orthographic verification procedure. This research indicates that the visual orthographic features of words are ubiquitously activated by pseudohomophones. According to Ziegler and Jacobs (1995) the Dual Route Cascaded model predicts that pseudohomophones activate the phonological output lexicon that cascades activation to whole-word units in the orthographic lexicon that in turn feedback to the grapheme level. The cascaded action of the Dual Route Cascaded model resonates orthographic and phonological information to give an account of pseudohomophone effects and to indicate that orthographic information is also ubiquitously activated at the same time as phonological information.

More recent research by Ziegler, Ferrand, Jacobs, Rey and Grainger (2000) has indicated orthographic information is activated prior to phonological information on some tasks. The first experiment, on 8 adult participants, compared the response latency on identical visual orthographic features (B-B), with similar visual orthographic features (C-c), with dissimilar visual orthographic features (a-A), and with unrelated visual orthographic features. The different patterns of responses between the alphabetic decision task and the naming task indicated that phonological processing produced more inhibition than orthographic processing on these tasks. The tasks in Ziegler et al.'s second experiment were lexical decision and word naming and the stimuli consisted of phonologically identical and orthographically similar French word/nonword pairs, phonologically identical and orthographically dissimilar pairs, and phonologically dissimilar but orthographically similar pairs. The pattern of results indicated that orthographic priming was stronger for the lexical decision task and that phonological priming was stronger for word naming tasks. Ziegler et al.'s research confirms that task demands determine which cognitive processes will be initially activated. If the task is primarily visual as in lexical decision then the orthographic processor will be activated first, if the task is primarily phonological then the phonological processor will be activated first. This research also confirms that the degree of similarity between and contiguity of phonological and orthographic information produces the highest levels of facilitation.

Besner and Stolz (1998) performed research with two samples of University students that were tested for the pseudohomophone stroop effect and their results indicated that the "computation of phonology is difficult to prevent" (Besner and Stolz, 1998, p. 40). Even though the effects of the phonological processing of pseudohomophones were manipulated to hurt performance on the stroop tasks, phonological processing still occurred. Another series of experiments by Stolz and Besner (1998) using letter search and priming techniques on groups of university students established that orthographic and phonological processing is independent of morphological processing which in turn is independent of semantic processing. These experiments may indicate that different cognitive processes originate in different neurological modules and are activated by different task demands.

Luo, Johnson and Gallo (1998) replicated similar research to that of Lukatela and Turvey (1993). They differentiated between the pre-lexical phonological hypothesis and the direct visual access hypothesis. The pre-lexical phonological hypothesis embraces the automatic and ubiquitous activation of phonological mediation before a word is accessed in the mental lexicon. The direct visual access hypothesis embraces the direct orthographic access of word meaning from the mental lexicon. Their research studied the response latencies and error rates of 56 University students on three sets of stimuli; semantically related word pairs (e.g., DESERT-BARREN and FISH-NET), unrelated word homophone pairs that sound as though they are related (e.g., WOLF-BARE and SAND-BEECH), and unrelated word pairs that are controls of the homophone pairs (e.g., WOLF-BEAN and SAND-BENCH). The homophones hurt performance more than the controls indicating that pre-lexical phonological mediation is occurring and necessitating greater effort to inhibit incorrect responses. Their second experiment studied 26 university students on four sets of stimuli; semantically related word pairs (e.g., DESERT-BARREN), word-pseudohomophone pairs (e.g., TABLE-CHARE), controls of the homophone pairs (e.g., TABLE-CHARK) and word pairs that are unrelated (GROWN-ETHIC). The word-homophone pairs and word pseudo-homophone pairs did not differ significantly indicating that pre-lexical phonological mediation activates lexical access. Luo et al. propose that phonological mediation is automatic and fast, and that there is minimal evidence for a direct access to word recognition.

Rastle and Coltheart's (1999a) research with groups of university students has illustrated that lexicality is independent of nonlexical processes and that the phonological priming effects on homophones are only evident when words are present. Pseudohomophones (brayk/braik) and nonword homophones (keff/keph) do not facilitate priming when a prime/target pair does not contain a word. The Dual Route model maintains the independence of phonological and orthographic knowledge and the independence of the nonlexical and lexical routes to word recognition.

This research by Lukatela and Turvey, Luo et al. and Stoltz and Besner suggesting that phonological processing is fast, automatic, ubiquitous and affects the recognition of pseudowords constitutes a refutation of the dual route model that postulates the independence of the lexical and nonlexical routes. On the other hand, the research by Ziegler, Ferrand, Jacobs, Rey and Grainger, and Rastle and Coltheart provides counter evidence demonstrating that orthographical processing is under certain task demands ubiquitous and automatic. The combined evidence from these different schools of research seems to indicate that phonological and orthographical processes make distinct, separable and independent contributions to reading subskills and that contiguous grapho-phonological information facilitates responses.

III. Role of Strategic Control

The Dual Route Model allows the reader to make a strategic choice between the lexical and nonlexical route depending on the regularity of the word. In the Dual Route Model, lexical access is quick and automatic, and the nonlexical route is attention and resource demanding. The lexical route usually reads high frequency regular and irregular words quickly. Low frequency regular words are read relatively quickly using the nonlexical route, while low frequency irregular words require the two routes deciphering and competing to resolve the conflicting phonological and orthographic information. The lexical route is frequency sensitive with low frequency irregular words taking longer to recognise than high frequency irregular words and the nonlexical route is frequency insensitive with both low and high frequency regular words requiring grapheme-phoneme conversion to attain word recognition. Research by Bernstein and Carr (1996) sought to capitalise on the competition generated between the nonlexical route and the lexical route on low frequency exception words to study the affects of strategic control on pronunciation. The use of resource demanding tasks like memory load was observed to divert attention from the nonlexical route and facilitate lexical retrieval of low frequency exception words. The process of diverting attention from the nonlexical route to the lexical route is called the "release from competition" (RFC) effect. The research consisted of university students performing different memory tasks while reading blocks of high and low frequency exception words, and high and low frequency regular words. The pertinent results indicated that the digit and noun memory tasks produced the RFC effect where low frequency exception words were read more quickly under load conditions than under normal conditions. A subsample of the students revealed high levels of RFC effects with all memory load conditions. This research indicates that there is a dissociation between the nonlexical and lexical routes to word pronunciation and that memory load conditions can affect the strategy students adopt when reading.

Further support for the strategic control of reading routes to visual word recognition under memory load conditions has emerged from the research of Herdman and Beckett (1996). In three experiments on university students, Herdman and Beckett measured naming latencies and error rates on the reading of exception words and regular words with easy to hard digit memory loads (Experiment 1), dot memory (Experiment 2) and tone memory (Experiment 3). Experiment 1 also provided evidence of a release from competition effect where low frequency exception words were named faster when the digit memory load is hardest precipitating a suspension of the nonlexical route and an engagement of the lexical route. The results of a dot memory task in Experiment 2 indicated that the visual route is specific and can be dissociated from the nonlexical route. Generally, these results confirm the dissociation between the lexical and nonlexical routes, and the effects of strategy control.

Baluch and Besner (1991) observed strategic control in the reading of Persian words. The Persian script uses three vowels and three diacritical marks to designate vowels during the acquisition of reading and subsequently, fluent readers use a vowel-free script that omits these diacritical markers. The transparent script with vowel markers allows for the nonlexical route and the opaque vowel free script only allows for the lexical route. In one experiment fluent readers of Persian were split into two groups, one that read transparent words only and one that read transparent words mixed with transparent nonwords. The results indicated that the absence of nonwords facilitated the lexical route whereas the presence of nonwords facilitated the nonlexical route. These effects indicate the presence of strategic control and constitute evidence for a Dual Route model of reading acquisition.

Research by Monsell, Patterson, Graham, Hughes and Milroy (1992) on university students compared the naming latency and error rates for pure blocks of exception words and pure blocks of nonwords to mixed sets of exception words and nonwords, and mixed sets of nonwords with exception words. Naming latencies and error rates significantly increase with the mixed blocks of exception words and nonwords indicating that strategy control effects occur when the nonlexical route is engaged by the inclusion of nonwords. In another experiment students performed better in naming exception words and had fewer regularisation errors when they were presented in a pure block. These effects constitute evidence of a dissociation between the nonlexical and lexical routes to word recognition.

Hino and Lupker (1998) studied Japanese university students in a series of experiments using sets of Kanji and Katakana words and nonwords. According to the Dual Route model, Japanese Kanji words and English exception words are read using the lexical route even though Kanji words are written in characters that do not carry any phonological information and English exception words carry significant quantities of phonological information. Japanese Katakana words carry phonological information and have a more complex orthography than Kanji words. Katakana words can be read using the lexical and nonlexical routes depending on familiarity and frequency. A go/no go naming task required students to name words and to withhold the naming of nonwords. This task confirmed that Kanji words are more frequency sensitive than Katakana words and indicated that lexical and nonlexical processes were evident in the naming of Katakana words. However, when the go/no go task was combined with a lexical decision task the pattern of responses for the Kanji and Katakana words was the same and lacked frequency effects. This indicated that the naming task engaged phonological coding, whereas the lexical decision task engaged decision-making sub-processes. Hino and Lupker interpreted these results as indicating that different reading tasks engage different cognitive processes especially when the orthography carries varying levels of phonological cues (see also Coltheart et al., 2001).

Research in English has also focussed on distinguishing the effects of task demand and stimulus material on strategy control. According to the Dual route model, all nonwords including pseudohomophones are read using the nonlexical route but the nonlexical reading of pseudohomophones produces word recognition that can only be rejected by an orthographic verification process (Gibbs and Van Orden, 1998). The Dual Route model therefore predicts that blocks of words/nonwords and pseudohomophones will rely on the lexical route. However, when this was researched the pattern of results indicated the presence of nonlexical processes. Gibbs and Van Orden interpreted this anomaly as indicating the effects of task demand and stimuli rather than route selection and strategic control.

Kello and Plaut (2000) proffer two Connectionist interpretations of the strategy effect. The first is the time criterion hypothesis and the second is the input gain hypothesis. Kello and Plaut studied the responses of groups of approximately 30 University students in three experiments on a tempo naming task that compared the response latency and error rates of standard naming tasks and naming tasks that are paced by the tempo of beeps at incremental response rates. The results produce a typical pattern of consistency and frequency effects. However, the error scores were differentiated between

1) word errors where words with similar orthographical and phonological information were pronounced incorrectly,
2) legitimate alternative reading of components (LARC) where inconsistent words were pronounced as if they were consistent and exception words were regularised,
3) nonword errors where nonwords were mispronounced as words and articulatory errors where words were given incomprehensible or garbled pronunciations.

The results indicated that the error rates increased with tempo except for the LARC error rate that remained constant. The LARC error rate included regularisation errors and was indicative of the nonlexical route. The Dual Route model and the Triangle Connectionist models would both predict that a reduction of response time would prevent the completion of orthographic to phonological processing and increase regularisation errors. Instead regularisation errors remained constant indicating that lexical processes continued where nonlexical processes were thwarted.

The time criterion hypothesis anticipates that subjects set a minimum time to articulate a response to stimuli whether orthographical and phonological processing is complete or incomplete. The results, however, consistently indicated that subjects timed their responses to the onset of voicing and not to articulation or vowel information. Kello and Plaut, therefore propose that the route from orthography to semantic information to phonology could explain this pattern of responses. This hypothesis would rely on semantic information contributing to the relative decrease in regularisation errors as the tempo of naming increases. This suggested explanation does not happen in practice and would rely on semantic information contributing to word recognition ubiquitously and automatically in preference to sublexical and lexical information. Task demands may also contribute to the anomaly of the LARC errors, and the pattern of results of the other error scores is consistent with a de-emphasis of the nonlexical route and emphasis of the lexical route that is typical of a Dual Route interpretation of the data. A study by Balota, Law and Zevin (2000) on university students performing word and nonword recognition tasks also indicates that participants have flexibility in accentuating and attenuating attentional control to the different processing pathways in response to the effect of lexicality. They found that students were unable to simply process words by eliminating the lexical route and using the nonlexical route.

Research by Rastle and Coltheart (1999b) indicated that strategy control is evident in conjunction with serial position effects. When the irregularity was in the first position during left to right serial processing of word recognition the lexical route was engaged more definitively than when the irregularity was in the third position. Rastle and Coltheart studied the responses of university students to blocks of regular words or nonwords with filler exception words with first place irregularity compared with exception words with third place irregularity. The pattern of results from the exception words with first place position of irregularity indicated a slowing of the nonlexical route and some engagement of the lexical route whereas the pattern of results from the exception words with third place position of irregularity indicated a general slowing of the nonlexical route and negligible engagement of the lexical route. This result produces a clear indication of the effects of strategic control where subjects are either emphasising or de-emphasising their reliance on the nonlexical or lexical routes to adapt to the stimuli.

Berent and Perfetti (1995) also tried to reconcile the conflicting data that is emerging regarding ubiquitous and automatic phonological processing on the one hand, and strategic control on the other. They proposed that the autosegmental theory of phonology may resolve the current anomalies in the data. This theory maintains that the gestural utterances of speech are processed not linearly in one dimension irrespective of internal structures but in various multi-dimensional planes that incorporate several linguistic structures. According to the autosegmental theory, phonology consists of metrical and stress structures, tone, syllable structures and phonological structures pertaining to sublexical features. The two-cycle theory is based on the sublexical features of consonants and vowels. Gestural utterances are segmented into two distinct but interdependent planes one processing the acoustic signals of consonants and the other processing the acoustic signals of vowels. They intuitively anticipate that the processing of consonants is fast, automatic, ubiquitous and devoid of strategic control and that the processing of vowels is relatively slow and subject to strategic control. Berent and Perfetti conducted seven experiments on varying groups of university students to test their theory. The basic methodology is the mask-prime-target design. The target word RAKE is primed with RIKK to preserve consonantal information, with RAIB to preserve vowel information and RAIK to preserve both consonantal and vowel information. The results of the study indicated that the consonantal priming occurred during short exposures and vowel priming occurred during long exposures. Berent and Perfetti observed this pattern of results under several experimental conditions including stroop tasks, load conditions, complex versus simple vowels and frequency selected stimuli. The load conditions indicated that vowel processing was resource demanding. The frequency conditions indicated that regularity effects required long exposures for the processing of vowel information. Berent and Perfetti interpreted the effects in terms of lexical and nonlexical processing suggesting that consonantal information was processed quickly and automatically using lexical processes and vowel information was processed slowly using nonlexical processes and strategy control. However, they maintain a neutral stance between a Connectionist and a Dual Route interpretation of the data and postulate that their results indicate a more adequate explanation of nonlexical processes. Coltheart et al. (2001) analysed Berent and Perfetti's stimuli and observed that there was a confounding of vowels and position of irregularity effect that could account for the two-cycle theory as being an instance of the second position irregularity serial effect.

Lukatela and Turvey (2000) also administered the two-cycle experimental design to a group of university students using their own stimuli. Instead of replicating the results they found that the vowel information in the pseudohomophone KLIP primes the target word clip better than the consonantal preserving prime CLEP indicating that phonological processing of both consonantal and vowel information is fast, automatic and ubiquitous. A common observation of Lukatela and Turvey's results was that the greater the phonological and orthographic overlap (i.e., contiguity) between prime and target the greater the priming effect. Phonological priming, however, had a higher degree of priming ability than orthographic features.

5. Summary of the Psychometric Frameworks

From the neurological aspect the connectionist theory is grounded in neural-like networks that spread activation over the whole brain. The Dual Route theory is grounded in localised and specialised regions of the brain that form modules or inner lexicons and cascaded activation spreads between these modules (Coltheart et al., 1999; Coltheart et al., 2001). The neurological studies cited in this review favour the Dual Route account of separate and specialised neural locations that correspond to cognitive processes. Van Orden, Pennington and Stone (2001), on the other hand, argue that the Dual Route Model fails to produce the hypothesised pure cases and fractionise the brain into more and more dissociated modules.

The review of the performance of the Connectionist and Dual Route Cascaded models in simulating different forms of dyslexia once again favours the Dual Route account. The instances of dyslexia could be accounted for by a lesion occurring in different routes or modules while the division of labour hypothesis and the intrusion of simulated semantic input in the connectionist models did not convincingly account for the human performance of individuals with dyslexia either premorbidly or developmentally (Coltheart et al., 2001).

This review also cites research that suggests that a fast and ubiquitous activation of phonology excludes the possibility of a lexical route to pronunciation. Coltheart et al. (2001) agree that phonology is always activated and that this is a characteristic of the cascaded nature of the model but that this does exclude a lexical route to word pronunciation. They have also found evidence that the rate of activation of the lexical route is greater in intensity than that of the nonlexical route but that the nonlexical route is activated prior to the lexical route. This evidence suggests that the two routes do not compete with each other as in a horse race (Monsell et al., 1992) but rather are contributing to the process of achieving a response at different rates (Coltheart et al., 2001).

The research results by Coltheart and his colleagues that have evidence of left to right serial processing of print have not been accounted for by the connectionist models that require a parallel and lexical processing of print.

The research indicating strategy control has further supported the Dual Route Cascaded model in preference to connectionist models.

Coltheart et al. (2001) give a list[2] of twenty nine different observed human empirical phenomena that the Dual Route cascaded model has been able to simulate whereas the Connectionist models have not been able to account for many of these effects and data.

The Dual Route Cascaded model of word recognition and reading is the most complete computational model presently available and is able to successfully counter the attempts made to discredit its main tenets. This model also supports the contiguous presentation of orthographic and phonological information in the acquisition of spelling and reading. Psychometric and pedagogical theories vary in

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[2] The frequency effect, the lexicality effect, the regularity effect, the interaction of regularity with frequency, interaction of regularity with position of regularity, consistency effect, pseudohomophone effect, base word frequency effect on pseudohomophone reading, the absence of *N* effect on pseudohomophone reading, the presence of *N* effect on nonword reading, the whammy effect, the strategy control effect, homophone and pseudohomophone priming, repetition priming, the onset effect in masked form priming, triple interaction between regularity, frequency and repetition, the word length effect, the interaction of lexicality and letter length, word frequency effects in lexical decision tasks, pseudohomophone effects in lexical decision tasks, the interaction between pseudohomophone and orthographic similarity in lexical decision tasks, the *N* effect on NO responding in lexical decision tasks, the interaction between *N* and frequency on YES responding in lexical decision tasks (Coltheart et al., 2001, p. 251).

their field of endeavour and experimental design, consequently the pedagogical implications of the Dual Route Cascaded model are ambivalent. A close examination of the 238 rules that govern the nonlexical route to word recognition (for details see Appendix B) would constitute a significant challenge to English instruction (Rastle and Coltheart, 1999b). Coltheart et al. (1999, 2001) reiterate that they do not include a learning algorithm in recent applications of their models on the grounds that the architecture of their model corresponds to the functions of inherent, localised and specified modules of the cognitive system. Given that the human cognitive system is complex, Coltheart et al. consider that their model reflects the internal structure and functional architecture of that system. Certainly the pedagogical research of Treiman, Mullennix, et al. (1995) confirms that human subjects are able to reflect and grasp the statistical regularities in the English script. The debate whether these regularities are rule governed as in the Grapheme-Phoneme-conversion rules or frequency governed as in the Connectionist models is not of primary concern to this research. Both the Dual Route and Connectionist models capture the statistical consistencies and regularities of the Contiguous intervention and the harmful effects of graphemic and phonological variance contained in this present study.

6. Summary of Literature Reviews

The studies undertaken for this thesis are comprehensive in scope, and have required an extensive review of literature related to reading and spelling difficulties and development.

The research incorporates testing and intervention material. The testing material includes the reading and spelling of regular, exception and nonwords as well listening comprehension and standardised reading comprehension and spelling tests. The intervention material includes instruction in syllabification, phonemic awareness, phonological awareness and the alphabetic principle of mapping grapheme to phonemes and vice versa. The interventions also included instruction in identifying and recognising phonological variance for the phoneme intervention and identifying and recognising orthographic variance for the grapheme intervention and identifying and recognising frequently occurring spelling patterns in the contiguous intervention. The rationale associated with each of these components of the studies has necessitated a review of a broad range of literature related to reading and spelling acquisition.

The literature review has incorporated material from both pedagogical and cognitive psychological research where the objectives of the different disciplines sometimes merge and sometimes diverge. An attempt has been made to locate the present studies in the relevant material from both disciplines and to interpret the results in the theoretical frameworks of the dominant paradigms.

The literature review began by establishing the unique and distinctive role that phonemic awareness and phonological awareness possess in the acquisition of reading and spelling. The unique contribution of phonemic and phonological awareness was differentiated from competing factors that may affect the acquisition of literacy. The emergence of phonemic and phonological awareness along with the alphabetic principle was then shown to account for the learning of new and novel words through the application of a self-teaching mechanism derived from the development of these awarenesses. A review of cognitive research into reading mechanisms further substantiates the role of phonology and orthography in the acquisition of reading and spelling.

The literature review then traces the historical development of phonemic and phonological awareness along with the alphabetical principle and proposes that it is the contiguous presentation of phonological/auditory and orthographic/visual material that underlies the combined effect of phonemic awareness, phonological awareness and the alphabetic principle. The understanding that the contiguous presentation of phonological and orthographic material is critical to reading and spelling acquisition emerges from a confrontation with the phonological and orthographic variance that is demonstratively present in the deep orthography of the English written language. Research from both educational and psychological perspectives indicates that the statistically consistent and frequently occurring spelling patterns reduce phonological and orthographic variance, and increase learning potential.

The history and development of cognitive and computational models of reading and neurological observations of various forms of dyslexia also combine to indicate that phonological and orthographic processes make separate inputs to literacy, but when their inputs are unified and coordinated their contribution to literacy acquisition is maximised. Interference, on the other hand, in either input leads to costly compensations and trade-offs that are detrimental to the development of reading and spelling.

The collective material of the literature reviews indicates that the contiguous intervention of grapho-phonological information will be superior to either the graphemic or phonemic interventions alone. This researcher acknowledges the pre-eminent input that phonemic and phonological awareness makes to literacy and the independent contribution of orthographic information but argues that the key to literacy learning is located in the combined and contiguous presentation of both inputs.

Chapter Six METHODOLOGY

The main objective of this research was to investigate a quandary raised by Beck and McCaslin (1977) regarding the relative benefit of three approaches (one successive and two concurrent) to presenting children with letter-sound correspondences. Bloomfield and Barnhart (1961) argued that children should be taught a successive gradation of letter-sound correspondences (LSCs), whereby they first learn that there is a one-to-one correspondence between letters and sounds. Once the simple and direct correspondences have been mastered, the children can then be taught the digraphs, diphthongs and phonograms. Adams (1990) also postulated that children are less likely to become confused by LSCs if they are presented sequentially and successively from simple to complex. Byrne, Fielding-Barnsley and Ashley (1996) affirmed the benefits of teaching the invariant, consistent and transparent relationship between LSC so that students can grasp the alphabetic principle of mapping letters to sounds. Each of the approaches has advocates and adherents within the field.

Brand (1994) developed a program for reading instruction that is based on the successive presentation of exemplars of consistent phoneme-grapheme correspondences. This approach is also based on presenting children with official and invariant sound-letter and letter-sound correspondences. The Contiguous intervention of this study was based on groups of words taken from her material.

Spalding and Spalding (1969) pioneered a method of reading and spelling instruction based on the principle that children should be presented with variant and concurrent LSCs. Spalding and Spalding identified the major graphemic units (82) and systematically presented the variant sounds associated with these graphemic units. The Grapheme intervention in this study was based on their principle of presenting variant and concurrent LSCs.

Lamond and Whiting (1992) developed a program for reading instruction that was based on the phonemic awareness approach of listening to the sounds in words and transcoding phonemes to graphemes. This approach requires students to reiterate and analyse the sublexical sounds in words before assigning graphemes to the constituent sounds. This process of fine-grained phonemic segmentation inevitably confronts children with variant sound-letter correspondences (SLC). Part of their material encouraged children to sort words into a personalised dictionary where the analysed sound remains the same even though the grapheme(s) differs. Although their approach was not used in this study in its entirety, the Phoneme intervention is based on material taken from their sound dictionary that contains lexical exemplars of variant and concurrent LSCs.

The present study compared the effects of these three interventions on reading, spelling, and listening comprehension outcomes.

1. Research Design

The experimental research design for Study 1 and Study 2 is illustrated below in Campbell and Stanley notation (X = intervention and O = observational tests).

Grade	phase 1	phase 2	phase 3
2	O1	X	O2

Table 1 Research Design in Campbell-Stanley Notation.

The initial observation phase was followed by the intervention phase that was then followed by the final observation phase.

2. Methodological Approach and Justification

I. Identical Intervention Conditions

The procedures adopted in this research were designed to ensure that the three interventions maintained the same conditions except for the independent variable (Bryant, 1998; Gibbs & Van Orden, 1998). In each intervention the grapho-phonemic unit being detected was underlined. The cognitive abilities required to isolate these grapho-phonemic units remained the same but the cognitive processes being tested changed. The properties of the majority of words carrying these units were taken from children's reading programs to control for familiarity, frequency and age appropriateness (Brand, 1994; Lamond & Whiting, 1992; Spalding & Spalding, 1969). The task demands of some of the interventions required some unfamiliar and low frequency words to be selected, but the meanings and context of these words were discussed at the beginning of each lesson. Each lesson began with the introduction of 9-12 new words and care was taken that all the children identified and understood these words.

II. Order of Presentation

The order of presentation of the new words was graded for each of the interventions (Seymour et al, 1999). The pattern of gradation for each intervention was from a simple to a more complex grapheme to phoneme relationship (or vice versa). For the grapheme intervention this meant beginning with the vowels and moving toward the digraphs and polygrams. For the Phoneme intervention the beginning target sounds were short vowels and these progressed to the long vowels followed by a mixture of diphthongs and vowel blends, and consonants. The contiguous intervention began with the short and long vowels and then progressed through a mixture of digraphs, diphthongs, consonants and frequently occurring consonant blends and spelling patterns. In each graduation the pattern was to introduce increasingly less frequent patterns, or more complex sound blends or polygrams.

III. Equivalence of Practice

The amount of direct instruction and the length of time allocated to each of the interventions was the same (Seymour et al, 1999). New strategies and phonemic awareness instruction were introduced in the same way and at the same time. The interventions were administered successively and concurrently, so that each group was paced through the 20 lessons collaterally over time.

IV. Equivalence of Measurement

All of the participants were given identical batteries of pre-tests and post-tests administered by the researcher who maintained a consistent criterion of assessment and presentation of test material. Once again the testing was conducted collaterally (Seymour et al, 1999).

V. Equivalence of Learning Environments

The interventions were conducted in the same school at the same time to minimise the influence of extraneous unobserved variables on treatment outcomes (Huck et al, 1974). The first school was a public school with three very experienced teachers, two of whom were committed to a top-down approach and one to an interactive approach that incorporated a Lindamood Auditory Discrimination in Depth program (Lindamood, Bell, & Lindamood, 1992) as part of her curriculum. Another teacher had developed a style of teaching that fostered self esteem in the children by constant praise and affirmation within an enriched literary environment. The third teacher had developed a profound rapport with her students within a whole language approach. The differences between these teaching styles may have had an influence on the dependent variables in a way that could not be controlled.

The second school was a denominational school where the three normal classroom teachers varied in experience and maturity. The head teacher was the most experienced and she was responsible for the curriculum development and the assessment of all three classes. She chose the classroom spelling lists and tests, the literature and the teaching style for all three classes. Her approach was eclectic and interactive. The phonics material was introduced on an incidental basis and was not incorporated systematically into the curriculum. The second teacher was experienced and had taught for many years among Papua New Guinean native people. The remaining teacher was relatively inexperienced and during the intervention period was absent due to illness on frequent occasions. The impression of the researcher was that the second school provided a more consistent and common learning environment over the three classes than the first school and therefore minimised extraneous influences on the dependent variables (Wagner & Torgesen, 1987).

VI. Randomisation

The random allocation of students to the different intervention groups was not possible due to the length of the intervention and the limited resources of the researcher (Huck et al, 1974). However, all children in the existing classes were included in the research and statistical analysis was performed to evaluate the equivalence between the classes.

VII. How Much the Conditions Could be Manipulated

The independent variable was manipulated by the selection of specific words that contained the defining characteristics for each intervention. This meant that the selection of words for each intervention varied and the amount of priming between the interventions and the tests would have also varied to some degree (Huck et al. 1974).

VIII. Control Factors

Lack of Non-intervention Control

The presentation of variant grapho-phonological material is a relatively unconventional practice whereas the contiguous presentation is more accepted as conventional and would therefore act as a partial control to the first two interventions.

Inclusion of Intervention Control

The experiment did not contain an intervention that would control for the Hawthorne effect (i.e., the effects of experimental participation, per se) or for a non-phonemic awareness condition, and therefore lacked a measure for overall effectiveness (Huck et al. 1974). The battery of tests contained standard tests that were included to measure transfer and also to give some indication of the overall effectiveness of the interventions. Bryant and Bradley (1985) have also pointed out that nonword tests are measures of transfer since these items have not been encountered in previous listening or reading experiences.

IX. Naturalistic Ecology

The research was performed in the naturalistic setting of the classroom to emphasise the pedagogical validity of the outcomes. It was understood, however, that this could have limited the control of extraneous variables and the internal validity of the research.

3. Sorting Categories

I. The Sorting Task: A Cognitive Process

The task demands contained in the exercises for each of the intervention groups remained the same, while the content of each intervention varied. The stimuli and responses remained the same but the strategies required to identify the defining characteristics of each intervention varied (Gibbs & Van Orden, 1998). This was achieved by designing an exercise in which the participants sorted words according to a defining characteristic that exemplified the differences between the interventions. Bryant and Bradley (1985) commented that there was little known about the connection between the sound categories in words and their spelling categories. Goswami (1999) has reflected on learning novel words by analogy to known words, and recommends that children be taught to categorise words by analogy and that the greater the number of exemplars within an analogical category the greater the facilitation to learning. The task of sorting words into categories is part of the more fundamental cognitive skill of categorisation that leads to concept formation, assists perception, aids memory, and facilitates problem solving and linguistic behaviour (Gillet and Kita, 1979).

II. History of the Sort

Henderson (1980) from the University of Virginia began his own pedagogically orientated research based on the insights of Read (1975) and encouraged other researchers to join him. Henderson (1980) was committed to developing the cognitive skill of sorting words according to defining characteristics. His fellow researchers Gillet & Kita (1980) and Zulzy (1980) both reported their findings and experiences using this methodology. Gillet & Kita's (1980) research led them to promote the teaching practice of the sort as a means of enhancing children's cognitive growth. Zulzby's (1980) experience with teaching children to sort words indicated that children develop from sorting words on the basis of rudimentary and surface characteristics to more adult and conventional features. Both Morris (1982) and Henderson (1981) argued that learning to read is a psycholinguistic skill and not a guessing game. Morris (1982) used the word sort to help children to understand the functional use of the silent 'e' marker by sorting single syllable words either possessing or not possessing the silent 'e' marker and by targeting the sound of the vowel as the defining characteristic. The word sort has been used by Barnes (1989a & 1989b), Fresch & Wheaton (1997), Bear and Templeton (1998) and Heald-Taylor (1998).

III. Theoretical Orientation of the Sort

Henderson (1980) and the Virginian School of researchers encouraged children to discover for themselves the structures and patterns governing English spelling (Zutell, 1980). Children learnt for themselves, and developed their own cognitive and linguistic proficiency by actively exploring the material. The word sort involved the children in physically manipulating the cards and categorising the words or sounds. On this basis the children generalised their learning experiences to novel items (Gillet & Kita, 1979).

When children actively searched for likenesses and differences among the targeted defining characteristics there was a convergence of the orthographic information and the phonological information, with the cognitive processes. Through manipulating and categorising the various word patterns children came to internalise English orthography. The word sort could then contribute to children acquiring accuracy, fluency, automaticity and the ability to generalise their knowledge of orthographic and phonological information to novel words (Morris, 1982).

Henderson & Templeton (1986) claimed that the acquisition of spelling skills was more closely related to the development of linguistic and cognitive processing skills than to either visual or auditory discrimination, or rote memorisation abilities. Their research has indicated that children acquire abilities to analyse linguistic patterns and knowledge through a series of developmental stages from simple to complex material. The word sort is one tool that has been used effectively to assist children in gaining cognitive skills to process these linguistic patterns where these patterns consist of components of word knowledge that constitute a composite of syntactical, semantic, orthographical and phonological information (Barnes, 1989a, & 1989b).

A student orientated perspective on teaching spelling and word knowledge integrates a number of learning environments. It includes direct instruction from the teacher and interactive learning on the part of the students. The discrepancy between the individual learning experiences of the participants and those of a mature language user has been described as the zone of proximal development. Participants were encouraged to move through this space with the assistance on the one hand, of scaffolding provided by the teacher and on the other, by collaborative learning with other participants. Ideally the stimuli in the intervention would also have been selected from the reading and spelling material of the normal classroom but the limited resources of the researcher and the reliance on source materials for the intervention have prevented this. Interactive elements of student orientated learning were incorporated. The participants were placed in pairs for peer support, and these pairs were placed in groups, and group conferences as well as conferences with the teacher were encouraged and emphasised. Metacognitive conferences were also encouraged where the students were asked to reflect on the information they were processing, and to discuss and articulate the patterns that were being studied and analysed. They were also encouraged to articulate what the implications and applications of these discoveries would be for their future spelling and word identification (Foorman, Francis, Fletcher, Schatschneider, & Mehta, 1998; Foorman, Francis, Shaywitz, Shaywitz, & Fletcher, 1997; Heald-Taylor, 1998)

Foorman et al. (1997) have argued that reading and spelling involve both the phonetic module that is innate and biological, and the written language that is culturally transmitted and arbitrary. The match between phonological and orthographic information is 50% regular, 37% predictable in all but one sound and 13% dependent on word specific knowledge according to the research of Hanna et al. (1966). Coltheart et al.'s (1993) computational model was able to analyse 78.17% of a substantial sample of monosyllabic Australian words by a specific set of grapheme-phoneme-conversion rules and Zorzi et al.'s (1998b) computational model rendered regular 81% of a substantial sample of monosyllabic words. The predictable portions of the English language could be re-invented by discovering the statistically and frequently occurring patterns of similarities and differences in the Piagetian and Wittgensteinian sense (Foorman et al., 1997; Wittgenstein, 1953). The exceptional, strange, unique and seemingly arbitrary portions of the language might require guided instruction in the Vygotskian sense (Foorman et al., 1997) whereas the regular, rule governed and consistent portions of the language seem to reflect the innate biological structure of the phonetic module proposed by Liberman (1997) and the deep grammatical structures proposed by Chomsky and Halle (1968) (Foorman et al., 1997; Pinker, 1998).

IV. Effectiveness of the Sort

Fresch and Wheaton (1997) have implemented the word sort within a child centred program of spelling instruction. They propose that the method integrated word knowledge with practical strategy development to assist children in learning to fully analyse words. They substantiated their claims by the qualitative criteria of self-reports that confirmed that the participants were learning effective spelling strategies. Bear and Templeton (1998) also substantiated their use of the word sort on qualitative self-reports of their students. Children are naturally curious about words and the word sort enables them to exercise their curiosity in a way that explores and discovers frequent patterns of word knowledge.

Joseph (1999) used word boxes to instruct children that had learning difficulties and a low baseline score on word identification on how to spell. These children were experiencing difficulties identifying, sequencing and positioning grapheme-phoneme correspondences and were still unable to analyse words beyond initial and final consonants. Joseph (1999) plotted the number of instructional sessions needed to achieve a mastery criterion for six students. The students varied between 5 and 18 sessions before there was a sharp qualitative progression from the baseline to a mastery level of performance. The students that internalised the orthographic and phonological structure of words also gained automaticity in their ability to identify and spell words (Joseph, 1999).

V. Adaptation of the Sort

The word sort in this experiment has been adapted to focus on different relationships between orthographical and phonological information. The word sort and word boxes have been implemented to devise a series of exercises to help the participants identify the sounds or graphemes or both in a set of novel words and to categorise them according to specified defining characteristics.

4. Contiguity and Interventions

Research by Berninger and Abbott (1994) indicated that interventions containing multiple layers of connections between orthographic and phonological information were more effective than single code interventions. The single code interventions consisted of instruction in simple grapheme-phoneme correspondences (e.g., bat) whereas multiple connections taught a range of connections that included silent relational markers (e.g., game); polygrams (e.g., wish); digraphs (e.g., rain); letter doubling (e.g., hill); liquid modified vowels (e.g., first) and arbitrary silent markers (e.g., wrong) (Berninger, Abbott, Brooksher, Lemos, Ogier, Zook &

Mostafapour, 2000; Berninger, Vaughan, Graham, Abbott, Brooks, Abbott, Rogan, & Reed, 1998). Berninger et al's research (1998, 2000) combined varying layers of orthographic-phonological information with varying instructional interventions. The results indicated that first grade children improved the most when instruction commenced with the predictable letter-sound correspondences followed by the moderately predictable letter-sound correspondences and finally the least predictable letter-sound correspondences (Berninger et al., 2000).

Deavers and Brown (1997) researched children from grade 1 to grade 5 on spelling consistent and inconsistent words. The spelling of nonwords analogously with inconsistent words indicated that the students were using a strategy based on onset and rime units. The results confirmed that children of all age groups use a combination of strategies that manipulate both large and small units of phonological and orthographical information when presented with cue words.

Research by Uhry and Shepherd (1997) indicated that multi-level interventions accompanied by the delivery of direct instruction in letter-sound correspondences, phonological awareness and whole word instruction improves the performance of children (n=12) with a phonological recoding deficit on measures of reading and spelling. Vandervelden and Siegel (1997) conducted similar research that administered an intervention and direct instruction in phonemic and phonological awareness to 30 grade 1 children. The results indicated that the intervention developed greater skill in the experimental group in pseudo-word reading and spelling compared to a control group that was given equal time under similar conditions working on classroom material. Further research by Torgesen, Wagner, Rashotte, Rose, Lindamood, Conway and Garvan (1999) also indicated that the administration of eighty-eight hours of instruction in phonemic decoding to children from kindergarten to second grade improved their phonological awareness, phonemic decoding skills and context free word reading in contrast to children supported by regular classroom reading programs or phonics embedded programs. However, the groups did not differ in their development of comprehension skills.

Although some previous research indicates that interventions in phonemic awareness have been effective, other research has been relatively limited in obtaining significant outcomes.

5. Interventions, Contiguity and Transfer

Lovett, Warren-Chaplin, Ransby, and Ransby (1990) administered a 35 hour intervention to 54 primary students with specific reading deficits. There were three experimental groups, one received a whole word presentation, another received a grapheme-phoneme segmentation presentation and another, the control group, received training in problem solving and self help skills. The posttests consisted of some words that had been taught and some that had not been taught in the intervention. Both of the experimental groups outperformed the control group but only on the test material that had been taught in the intervention. Lovett et al. (1990) interpreted these results as indicating that the whole-word and the segmentation interventions assisted children to acquire word specific information but not to abstract sublexical information that facilitated the recognition of unfamiliar words and nonwords. However, research by Barron, Lovett and McCabe (1998) on students with dyslexia that received an intervention using a talking computer and given segmentation feedback did achieve greater transfer on a word and nonword recognition test than those given whole word feedback.

Greaney, Tunmer and Chapman (1997a, 1997b) administered an eleven-week intervention on 36 children with reading deficits. One group was given metacognitive strategy training on rime analogy and the other group was given metacognitive strategy training on item specific material that contained contextual clues to identify unfamiliar words. The group that received rime analogy training outperformed the group that received the item specific training on standard reading tests. Greaney et al. (1997b) interpreted their results as indicating that a combination of phonological awareness, rime analogy and metacognitive training for children with reading deficits facilitated the transfer of learning from taught to untaught tasks.

Collectively this research indicates that children receiving explicit instruction in phonemic segmentation, phonological awareness and strategy training will be able to transfer their learning to standard tests and test materials that have not been specifically taught in the intervention. The post-tests in the present study contained material that was not specifically taught during the intervention phase of the study.

6. Participants

The sample consisted of grade 2 children that came from the North Shore of Sydney. The children in the first study attended a public School while the children in the second study attended a denominational primary school. The location of these schools could be considered as an upper middle to lower-upper class area. MacLean, Bryant and Bradley (1987) have studied the relationship between social class and phonological awareness. Their sample consisted of 66 children from the South of England who had an average age of 3 years, 4 months at the commencement of the study and the study lasted for 15 months. The social class of the father and the education level of both the mother and the father were obtained. The children were assessed for phonological awareness and knowledge of nursery rhymes. The results of the interventions demonstrated that children of 3 years of age could acquire phonological awareness, that nursery rhyme knowledge does predict subsequent phonological development and that the phonological skills assessed at 3 years of age can predict the subsequent commencement of reading. In particular, these results where obtained while no consistent effects of social class or the educational levels of the parents were evident. Kirtley et al. (1989) and Bryant et al.'s (1990) further analyses indicated that social background and mother's education could be statistically controlled to isolate evidence of phonological awareness and its causal relationship with reading and spelling. This research has indicated that rhyme/alliteration training and phonemic awareness are interrelated and contribute to the development of reading and spelling skills independently to social background and parental educational levels.

Mother's educational level measured in number of years was included in a study of phonological representations on 91 Danish children (Elbro et al., 1998). The participants began the study at age 6 and the study lasted two years. Mother's education did not statistically contribute to the reading development of their children indicating that this aspect of family background may be independent of the acquisition of literacy skills. One aspect of family background that was predictive of reading development was the reading status of the parents. A reading status of dyslexic was attributed to parents with low decoding ability. The amount of time spent reading to the children was also not a significant predictor of reading acquisition in this research (Elbro et al., 1998).

Nicholson (1997) has found that social class does have a significant effect on learning outcomes. Middle-class children tend to have acquired phonological processing skills before commencing school while children from low-income families enter with relatively fewer phonological processing skills and consequently, are disadvantaged, particularly when confronted with whole language instruction. Nicholson (1997) cites other collaborating research that indicates that middle class children benefit from preschool experiences with phonological awareness while children from low-income families are relatively deprived of these linguistic experiences.

The implications of social class and/or parental educational levels may affect the external validity of this research, however, the initial advantageous effects of social background may have been minimised after two years of schooling and therefore may not adversely affect the generalisability of this research to other grade 2 classrooms.

It would appear that the possible causal relationship between factors pertaining to phonological awareness, and reading and spelling acquisition may remain valid even when social background deprives children of the advantages of pre-school literary experiences.

I. Sample Appropriateness

This experiment was not designed to differentiate between within-sample groups of children (i.e. children who can or cannot perform a specific skill) or to determine the cause of reading difficulties. The aim of this experiment was to assess the effects of different intervention conditions on classes of children that are otherwise equivalent. One limitation on the generalisability of the results from this research is that the sample is taken from grade 2 classes and the intervention effects are therefore specific to this age group. Further experimentation would be necessary to determine if similar intervention effects could be obtained with either older or younger reading age groups.

II. Sample Size

The sample size was selected to approximate to a ratio of ten students for each of the dependent variables to maintain the power of the statistical procedures used. There were nine dependent variables and approximately eighty students in each of the studies.

Chapter Seven STUDY 1

1. Aims of the Research

The aim was to assess the effects of three different interventions on grade 2 students' ability to read and spell, regular words, exception words, and non-words, as well as normed reading/spelling and listening comprehension tests.

2. Research Questions

The major research questions addressed were:

1) Were the concurrent Grapheme or Phoneme interventions more beneficial than the contiguous successive intervention for improving reading/spelling and listening comprehension skills?
2) Did the Grapheme and Phoneme interventions differ in their effects on these dependent variables?
3) Did the pattern of effects for the three interventions vary across the different measures of reading and spelling skills (eg., regular words, exception words, non-words, and listening comprehension tests)?

3. Dependent Variables

I. Rationale for Test Selection

Students' ability to read and spell was assessed using measures that were specifically constructed to include regular, exception, and non-words, as well as by standardised reading, spelling and listening comprehension tests. (For test used in this experiment see Appendix C).

Castles (1994) and also Coltheart, M and Leahy (1996) have constructed an instrument for detecting improvements in reading skills that consists of reading lists of regular, exception and nonwords and their lists have been incorporated into this research. The same instrument has been generalised by this researcher to assess spelling.

A test of listening comprehension has been included in the study as an essential component of reading acquisition. Research by Nicholson (1986) and Aaron (1989) has indicated that reading is a function of decoding skills and listening comprehension (see also Nation and Snowling, 1998). (See glossary for a diagram of Nicholson's model of reading abilities.) Nicholson proposes that decoding ability and listening comprehension are dissociated. The ability to decode can be measured by a student's capacity to read nonwords and regular words that conform to the

Grapheme Phoneme Conversion rules of Coltheart's Dual Route model (1978) (see also Metsala, Stanovich and Brown, 1998). Whereas listening comprehension is a measure of a child's reading comprehension (Aaron, 1989) and therefore a full measure of reading development requires an improved performance on both decoding ability and listening comprehension. Children who have a significant discrepancy favouring decoding ability over listening comprehension are referred to as hyperlexic. Children who have a significant discrepancy favouring listening comprehension abilities over decoding skills are referred to as dyslexic or having a specific learning difficulty in phonological awareness. The test of listening comprehension was therefore included to measure the effects of the different interventions on this subcomponential reading ability. The tests of nonword and regular word reading and spelling were included to measure pre-post changes in decoding ability, whereas the tests of exception word reading and spelling were included to measure changes in lexical and word specific reading ability (Aaron, 1989; Castles, 1994; Coltheart, M and Leahy, 1996; Nicholson, 1986).

4. Method

I. Participants

The sample for Study 1 comprised 76 children from three Grade 2 classes of a local public school. The location of the school was on the lower North shore of Sydney where the socio-economic status was high. Written consent was obtained from the parents of all the children and approval to conduct the project was obtained from the University ethics committee. The experimenter conducted all instruction during the interventions and the teachers were free to come and go from their classrooms.

Grade 2 students were chosen because there is evidence to suggest that the literacy and emotional development of children at an earlier age may be subject to some degree of instability (Elbro et al., 1998; Prior, 1994).

The age range of the children was from 7 years 4 months to 8 years 8 months (M = 7 years 11 months, SD=3.73). There were 40 girls and 36 boys. Data for all of the children were included in the final statistical analysis.

There was also a subpopulation of 16 students for whom English was a Second Language (ESL). The progress of these students was monitored and later statistically analysed to assess the effects of differing cultural and linguistic expectations in regards to the presentation grapho-phonological material (Brown, 1990).

II. General Overview of the Program

i) Interventions

The interventions were derived from the principles underlying three different approaches to presenting grapheme-phoneme relationships.

The Contiguous Intervention. The Contiguous intervention presented words where the graphemic unit consistently represented the same phoneme. A selection of words was taken from the Brand (1994) program, where the graphemic units carried the same phonemic content. An example of the words used in the sixteenth lesson of this intervention were:- hair, touch, was, young, wasp, pair, country, stairs, couple, double, squash. The target letters were underlined and the defining characteristic that the children sorted was the words that contained the same grapho-phonological information. (See Appendix A for a complete list of all words used.)

The Phomene Intervention. The Phoneme intervention demonstrated to children the range of different graphemes that could be used to represent a single phoneme in the English language. A selection of material for the Phoneme intervention was taken from the Sound Dictionary of the Lamond and Whiting (1992) program, where words of different graphemic units were grouped according to their common sound (i.e., phonemic unit). For example, in lesson 19, the students were given the following words to sort according to the sound of the underlined letters:-

horse, sore, broad, soar, pour, door, war, chalk, paw, fault, sure, thought. The target letters were underlined and the defining characteristic that the children sorted was the different graphemes that the same phoneme represented.

The Grapheme Intervention. The Grapheme intervention demonstrated to the children the range of different phonemes that a single grapheme could represent in the English language. A selection of material was taken from the Spalding and Spalding (1969) program that illustrated how a single graphemic unit could represent different phonemes. For example, the students were given the following words in Lesson 17 to sort according to the different sounds of /oo/:- hoop, book, door, snooze, shook, poor, shampoo, boorish, goodness, woo. The target letters were underlined, and the defining characteristic that the children sorted was the different sounds that these letters represented.

ii) Design of the Instruction Program

The interventions were designed for student-centred teaching where the children were encouraged to engage in discovery learning (Gaskin, Ehri, Cress, O'Hara and Donnelly, 1996). In each lesson, the children were given four tasks. The form of the work-sheets for each of the interventions consisted of the same exercises and instructions, and only differed in the selection of words introduced with each lesson. The duration of the intervention was 10 weeks, and consisted of two half-hour lessons per week. The students were not tested or required to learn material outside of the lessons. The worksheets acted as a source of accountability for the research procedures, and provided concrete feedback to the experimenter of the students' progress in completing the exercises. They also allowed the students the opportunity to express their impressions of the lessons.

The first task required the children to sort words according to a specified criterion, the sound of the letters underlined in each of a group of twelve words. The words were scripted onto separate cards. The following instructions were given to all the students for the first twelve lessons:-

I would like you and your partner to sort the following words into piles.
Take a card and say the word slowly.
As you stretch out the word, listen carefully to the sounds in the word.
Listen carefully to the sounds underlined.
Put down one card that you have worked on.
Take another card. Does the underlined letter(s) have the same sound as the first card?
When the underlined sound is the same, put the card on top of the other card.
When the underlined sound is different, make a new pile.

Instruction Set 1.

The students were given cards to sort according to the above instructions. On the basis of the pretests, the students were seated in pairs where one child was relatively more competent than the other. The children were told that they should help one another and that copying each other's work was not cheating, but allowed. The students were also encouraged to ask the experimenter for the correct pronunciation or meaning of any of the words in the lesson. The first pair of students to complete the sorting was asked to present their sort to the class on a voluntary basis. After a few weeks it became necessary for the students to take turns in presenting their sort. The experimenter checked the sort before the children made their presentation to the rest of the class to prevent possible embarrassment. This opportunity acted as a reward for some students.

During the first few lessons the experimenter modelled the instructions, and then the children were encouraged to sort their words. Identical instructions, modelling and peer collaboration were implemented in each of the interventions.

The above written instructions were abbreviated after twelve lessons, for three reasons,

1) the children were being constantly reminded of the procedure both by modelling and verbally by the experimenter,
2) the children were observed not to be reading the instructions and
3) the space on their work sheets was required for other work. The abbreviated form of the instructions read as follows:-

Sort the cards by listening to the underlined letters. If the sounds are the same put them together. If the sounds are different put them in a new pile or put them in the miscellaneous column. Do the letters show you the sounds? When you hear the sound will you know the letter/s?

Instruction Set 2.

The second exercise required the students to count the letters and then the sounds in the new words that were introduced in the first exercise. During this process they were asked to identify the "tricky spots" where the number of letters was different from the number of sounds that they heard.

The third exercise provided the students with consonants and consonant blends on the one hand, and a group of rimes to which they could add the consonantal onset, on the other. The children were rewarded for the number of words they could make from the rimes. The students were simply given the following question.

Can you make other words from these bits?

Instruction Set 3.

The material for this exercise was developed from the research of Stanback (1991 & 1992) who has compiled a list of rime patterns from a sample of 17,602 frequency-based words.

The final exercise was a revision of the words from the previous three weeks, where the students were encouraged to once again sort the words used during the three previous sessions into clusters. (See sample lessons in Appendix A.)

iii) Rewards

For the first twelve weeks, the students were continually rewarded for their efforts by stamps when their work was marked. In the last few weeks the marking and stamping became more discriminatory and less frequent. The children were given verbal praise during the lessons whenever a contribution was made to the process of sorting the words. The children were also given a pencil at the time of pretesting, and a ball point pen at the time of posttesting, as a form of encouragement and to enhance motivation. It was also specified that these rewards were given in appreciation for their work and participation in the programs. Rewards were identical across the three experimental conditions.

iv) Tests and Test Construction

Waddington Diagnostic Reading and Spelling Tests. The Waddington Reading (WR) test was administered both as a pretest and posttest. This test contained 60 graded items that tested for alphabetic knowledge, word knowledge, semantic, syntactical, subject and sight word knowledge using close and multiple choice material.

The Coltheart Reading Test contained 90 items that were randomly presented to the children on flash cards. The 90 items consisted of 30 regular words, 30 exception words and 30 nonwords. Coltheart, M and Leahy (1996) have norm-referenced this test on 420 students. It was administered as a pretest.

Reading Post-Test: Coltheart, M and Leahy (1996) provided only one version of this test. To minimise test-retest confounding effects, parallel forms of the regular and exception word sections were developed for use in the posttest. The nonwords (30) for the pre- and posttests remained the same, given that students were considered less likely to recall these. The regular and exception words were taken from Carroll, Davies and Richman's (1971) *American Heritage Word Frequency List*. The regular (30) and exception (30) words were matched for frequency, number of syllables, number of letters and regularity. Anne Castles, an experienced researcher in the area who used a similar list of words in her Ph.D. thesis (Castles, 1994), then provided critical feedback on this new set of items. She judged the face validity and the comparability of the new item set to the original test as high. The Coltheart reading pretest and the reading posttest obtained a correlation coefficient of 0.88 for regular words and 0.84 for exception words in this research. Although these correlations included the effects of the study itself, they did suggest that the two tests were highly correlated.

The Listening Comprehension Test: This test was one collated by Brigance (1983). The test consisted of a series of short passages of prose followed by 5 questions. A student was permitted to progress to a higher level of difficulty if they answered at least three questions correctly. The scale of passages ranged through lower first, upper first, lower second, upper second, lower third, upper third, fourth, fifth, sixth and seventh levels. The scores were recorded on a nine-point scale. On the pretest, testing began at the upper second grade level, which was commensurate with students' grade level, and adjustments were made in response to their performance on this initial exposure to the material. Their achievement level on their pretest guided the starting point for the posttest.

Pre and Post Spelling Tests: The spelling tests were all constructed by the same process as the reading test (for details of the tests see Appenix C). Words were selected from the American Heritage: Word Frequency list by Carroll, et al. (1971). For the spelling pretests, twenty words were randomly selected from the 600 most frequent words in Carroll et al.'s rank order list. These words were then sorted into regular and exception words according to Venezky's (1971) criteria of major and minor letter-sound correspondences. The exception words were then matched to obtain a full complement of regular words and the same process was used to obtain a full complement of exception words. Two experienced teachers then reviewed the tests for acceptability and level of difficulty. They were next given in three grade 2 classes at the local public school and the results analysed. The tests obtained internal consistency reliabilities above 0.8. A test of twenty nonwords was constructed by editing letters from the regular words, and then subjected to the same procedure as above with the same result. This procedure was again followed to construct grade 3 regular word, exception word and nonword tests, only the frequency of the words from which the random sample was selected consisted of words, listed in Carroll et al, between 400-1000 on the rank order list of most frequent words. Once again the internal consistency reliabilities were above 0.8 for the grade 3 students.

The regular word, exception word and nonword tests used for the posttest of Study 1 were the tests constructed for the grade 3 students and the level of difficulty may have been too high for the grade 2 experimental students and may have masked reading improvement levels.

Waddington Spelling (WS) Test. The WS test was administered both as a pretest and as a posttest. The period of time between testing was three months. This test is normed on Australian students and contains 70 items that test for alphabetic knowledge, consonant blends, simple and complex digraphs and diphthongs, long vowel sounds and commonly used sight words.

The South Australian Spelling Test (SAST). This test was administered by the school, and the data made available to the researcher who included it in the statistical analysis. This test was only included in Study 1 as the Waddington test was the preferred means of assessing spelling progress.

The only tests to be individually administered were the reading tests (i.e., 90 words) and the Listening comprehension test. Together these two tests occupied about fifteen minutes of the student's time.

(For tests used in this study see Appendix C.)

5. Results

To compare posttest scores for students in the Phoneme, Grapheme, and Contiguous intervention conditions, scores were grouped into two conceptual sets (reading and spelling achievement) and separate multivariate analyses of covariance (MANCOVAs) were then performed on scores in the two sets. In each case, corresponding pretest measures were used as concomitant variables.

Univariate ANCOVAs were applied to assess the effects of the two factors on individual dependent measures. Stepdown analyses (Roy & Bargmann, 1958) were also performed for correlated measures within each set. The Bryant-Paulson procedure (see Bryant & Paulson, 1976 cited in Stevens, 1994), which is an extension of Tukey's WSD (Tukey, 1953 cited in Stevens, 1994) procedure for random concomitant variables, was used for all post-hoc comparisons of marginal means. All significant univariate outcomes were accompanied by effect size estimates based on the partial eta squared statistic (η^2).

To assess whether the effects of the three conditions differed across ESL and non-ESL students, ESL was initially included as a second independent variable in each analysis, producing a 2 (ESL) by 3 (condition) factorial design. However, these analyses produced no significant ESL by condition interaction effects, either on reading or on spelling achievement ($V = 0.10$, $F(8,128) < 1$; $V = 0.21$, $F(10,126) = 1.45$, $p = 0.17$, respectively), indicating that the effects of condition did not differ across ESL/non-ESL students. There were also no significant main effects for ESL ($V = 0.09$, $F(4,63) = 1.55$, $p = 0.20$; $V = 0.06$, $F(5,62) < 1$, respectively), suggesting that the inclusion of this factor did not significantly reduce within-condition error variance. As a result, the ESL factor was excluded on all subsequent analyses including Study 2, collapsing the design to a one-way MANCOVA. This result indicated that children who have English as a second language were benefiting and developing their literacy skills commensurately with the native Australian English language students.

Assumptions for Uni-Multivariate Analysis of Variance.

Screening procedures for the three sets of scores suggested adequate conformity to univariate and multivariate analysis of variance assumptions. Mahalanobis distances, calculated separately for each of the three cells of the design, indicated no multivariate or univariate outliers ($ps > 0.05$), and all tests for heterogeneity of variance and dispersion matrices were nonsignificant ($ps > 0.05$). Assumptions of univariate and multivariate normality were judged to be tenable, although there was some evidence of non-normality on the Waddington reading posttests. As this may result in a reduction of power for analyses involving this test

(Stevens, 1994), outcomes on this variable should be interpreted with some degree of caution.

I. Reading Outcomes

Overall Pretest-Posttest Gains

To assess whether students' reading skills increased generally from the pretest to the posttest across all conditions, scores on the five reading measures were subjected to a repeated measures analysis of variance (ANOVA). This indicated a significant multivariate difference between scores on the pretest and posttest (V = 0.81, $F(5,71) = 59.79$, $p = 0.00$). Univariate ANOVAs indicated significant increases from the pretest to the posttest on all of the dependent measures ($Fs(1,75) \geq 32.05$, $ps < 0.00$ $\eta^2 \geq 0.30$) except for the regular words test ($F(1,75) < 1$). It is possible that the nonsignificant effect on the regular words test reflects a difference in the difficulty levels of the two tests. As indicated in the Tests and Test Construction section, the posttest was originally designed for use at the Grade 3 level, whereas the pretest was designed for Grade 2.

Pretest Equivalence

Mean pretest scores on the regular word, exception word, non-word, LC and the WR tests were shown in Table 2. To determine whether pretest scores differed significantly across the three experimental conditions, a 3 way multivariate analysis of variance (MANOVA) was performed for pretest scores on the five tests. This indicated no significant multivariate effect for condition (V = 0.20, approximate $F(10,140) = 1.56$, $p = 0.12$). Univariate tests on the regular word, non-word, WR, and LC measures were also non-significant (all $ps > 0.10$).

Table 2 Observed Means (M_{ob}) Adjusted Means (M_{adj}) and Standard Deviations (*SD*) for Scores on the Pretest and Posttest Reading of Regular Word, Exception Word, and Nonword tests, the Waddington Reading Test and Listening Comprehension Test (n = 76).

Class		Reading Regular Words			Reading Exception Words			Reading Nonwords			Waddington Reading Test			Listening Comprehension		
		M_{ob}	M_{adj}	*SD*	M_{ob}	M_{adj}	*SD*	M_{ob}	M_{adj}	*SD*	M_{ob}	M_{adj}	*SD*	M_{ob}	M_{adj}	*SD*
Phoneme	Pre	25.18		5.54	16.61		4.67	21.25		7.33	40.61		6.15	4.00		2
Condition	Post	25.93	20.83	3.29	20.50	20.55	5.82	24.29	23.77	4.38	42.36	42.61	6.27	7.04	7.22	2
Grapheme	Pre	23.48		5.18	14.70		4.59	17.74		6.76	39.30		4.26	5.00		2
Condition	Post	23.57	24.60	3.92	17.22	18.49	4.55	21.48	22.89	6.20	40.83	42.04	5.25	6.39	6.30	2
Contiguous	Pre	26.56		3.95	18.24		3.74	21.40		7.12	42.24		6.64	4.00		2
Condition	Post	25.72	24.82	3.31	21.04	19.72	3.87	23.56	22.66	6.73	45.00	43.53	5.46	6.68	6.59	2

Note: For each of the reading tests the score was calculated on the number of correct responses. For the listening comprehension test the score was calculated as a grade level (at least 3 out of 5 correct answers to comprehension questions).

There was, however, a significant univariate difference on the exception words measure ($F(2,73) = 3.96, p = 0.02, \eta^2 = 0.10$). To reduce any bias this might introduce in the adjustment of posttest means, this measure was excluded from the pretest measure set. Despite this, the pretest difference found on the exception word test suggests that any significant posttest differences on this measure should be interpreted with caution.

Assumptions for Covariance Analysis.

With internal consistency reliabilities over 0.80 for scores on the exception word, regular word, and nonword tests, and a KR-20 reliability estimate of 0.97 for the Wadddington reading test, pretest scores on these measures were considered to be adequately reliable to use as covariates. Tests for heterogeneity of regression hyperplanes across the three cells of the design were nonsignificant in all multivariate, univariate, and stepdown analyses (all *ps* > 0.10), indicating that the use of the pooled within-cells regression coefficients to adjust cell means was tenable.

The multivariate association between combined pretest and composite posttest scores on the five measures was significant ($V = 1.69$, approximate $F(20,272) = 10.00, p = 0.00$), with univariate regression analyses indicating strong relationships between combined pretest scores and achievement on the regular words ($F(4,69) = 72.54, p = 0.00$), exception words ($F(4,69) = 58.00, p = 0.00$), nonwords ($F(4,69) = 25.64, p = 0.00$), WR ($F(4,69) = 74.25, p = 0.00$) and LC ($F(4,69) = 12.40, p = 0.00$) tests. Thus, use of the combined pretests as covariates produced a significant reduction in posttest error variance.

Outcomes

Observed means, adjusted means, and standard deviations for scores on the five posttests were also shown in Table 2. Based on the Pillai-Bartlett criterion, a significant main effect was found for condition on combined posttest scores ($V = 0.26$, approximate $F(10,132) = 2.01, p = 0.04$). Since a significant degree of overlapping variance was found between scores on the set of posttest measures (Bartlett's $\chi^2(10) = 33.60, p = 0.00$), both univariate and stepdown *F*s were used to assess the effects of the conditions on the five measures separately.

Given that one of the major goals of the three interventions was to increase reading achievement, the three word reading tests

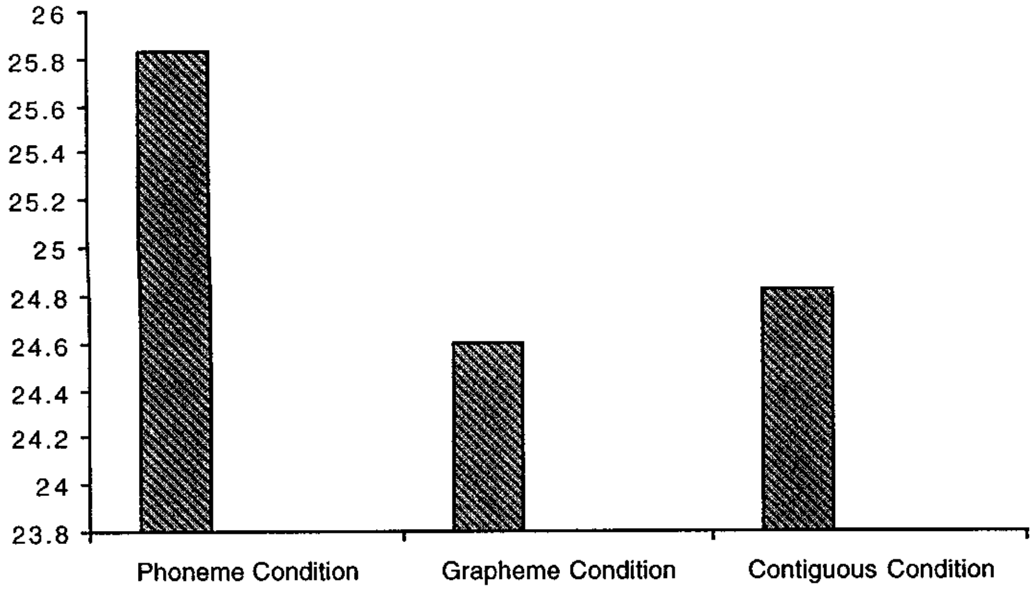

Figure 4 Adjusted Posttest Means on the Regular Word Reading Test for Students in the Phoneme, Grapheme and Contiguous Intervention Conditions.

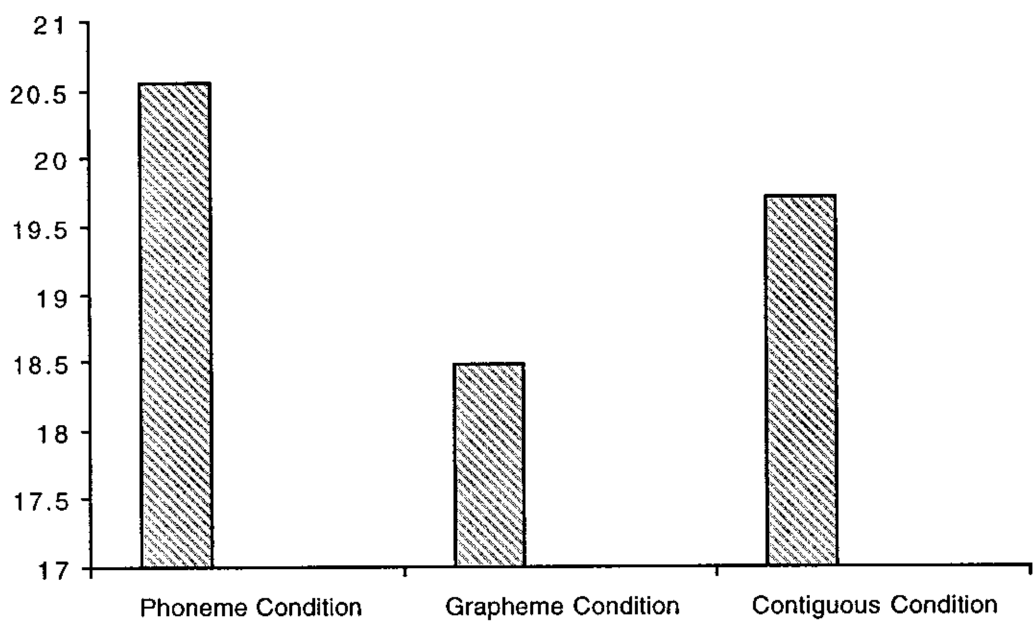

Figure 5 Adjusted Posttest Means on the Exception Word Reading Test for Students in the Phoneme, Grapheme, and Contiguous Intervention Conditions.

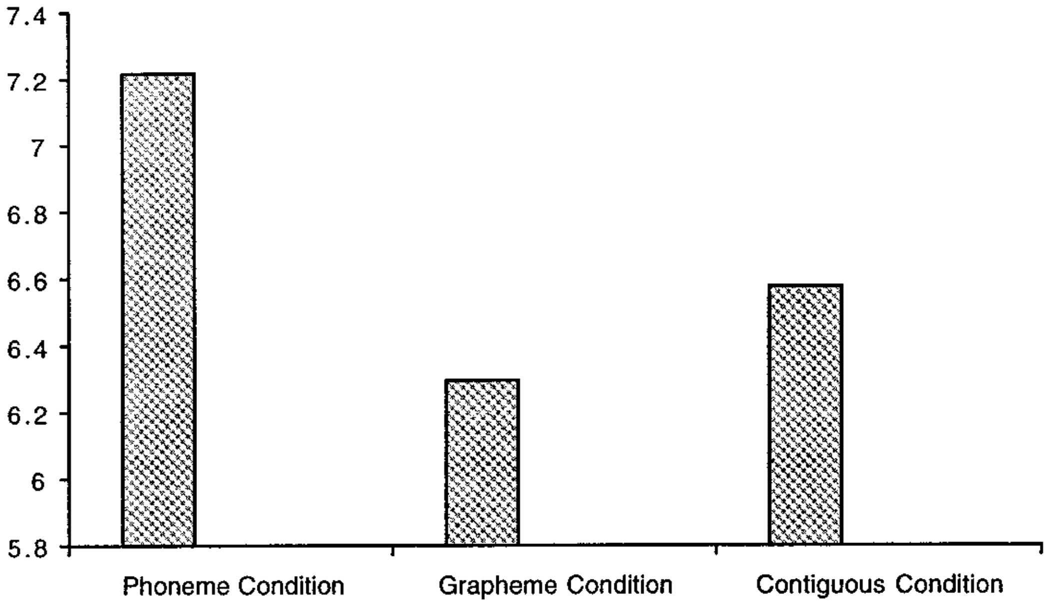

Figure 6 Adjusted Posttest Means on the Listening Comprehension Test for Students in the Phoneme, Grapheme, and Contiguous Intervention Conditions.

(i.e., of regular words, exception words, and nonwords) were entered prior to the WR and LC tests in the stepdown analysis. Since regular word reading is presumed to incorporate both orthographic and phonological processes, the regular word test was entered prior to the exception and non-word tests, while the latter two tests were assigned equal priority and analysed immediately after the regular word test (using an Bonferroni-adjusted α level of 0.025). The WR test, which assesses both sentence reading and comprehension, was in turn entered prior to the LC test.

The univariate ANCOVAs indicated significant effects on the regular word ($F(2,69) = 4.17, p = 0.02$, partial $\eta^2 = 0.11$), exception word ($F(2,69) = 4.27, p = 0.02$, $\eta^2 = 0.11$), and LC ($F(2,69) = 3.22, p = 0.05$, $\eta^2 = 0.09$) tests. The effects on the nonwords and WR were not significant ($F(2,69) < 1$; $F(2,69) = 1.95, p = 0.15$, respectively). The stepdown effects on the exception word and LC tests were also not significant (stepdown $F(5,67) = 1.96, p = 0.15$; stepdown $F(2,64) = 1.50, p = 0.23$, respectively), indicating that the univariate effects found on these measures were already accounted for in their shared variation with the regular word test.

The pattern of univariate effects found on the regular word, exception word, and LC measures were shown in Figure 4, Figure 5, and Figure 6 respectively. As indicated by these graphs, on all three tests, the Phoneme intervention students outperformed students in the other two conditions. Bryant-Paulson *qs* indicated that on each dependent measure, the Phoneme intervention students significantly outperformed those in the Grapheme intervention condition ($qs \geq 3.41$, $ps < 0.05$). Despite the clear trend to superiority for the Phoneme intervention over the Contiguous condition depicted in Figures 4-6, only the difference on the regular word test approached significance ($q = 3.16$, $p < 0.10$). For all three measures, there were no significant differences between the Grapheme and Contiguous conditions ($qs \leq 2.46$, $ps > 0.10$).

II. Spelling Outcomes

Overall Pretest-Posttest Gains

To assess whether students' spelling skills increased generally from the pretest to the posttest across all conditions, scores on the four reading measures for which a pretest was available, were subjected to a repeated measures ANOVA. This indicated a significant multivariate difference between scores on the pre- and posttests ($V = 0.55$, $F(4,72) = 22.55$, $p = 0.00$). Univariate ANOVAs showed significant increases from the pretest to the posttest on all of the dependent measures ($Fs(1,75) \geq 5.44$, $ps < 0.02$ $\eta^2 \geq 0.07$) except for the exception word test ($F(1,75) = 1.90$, $p = 0.17$). Again, it was possible that the non-significant effect on the exception word test reflected a difference in the difficulty levels of the pre- and posttests.

Pretest Equivalence.

Mean pretest scores on the regular word, exception word, nonword, WS spelling tests are shown in Table 3. To determine whether pretest scores differed significantly across the three experimental conditions, a one-way MANOVA was performed for pretest scores on the four tests. This indicated a significant multivariate effect for condition ($V = 0.24$, approximate $F(8,142) = 2.41$, $p = 0.02$). Univariate tests also indicated significant differences between classes on the regular word ($F(2,73) = 3.04$, $p = 0.05$), exception word ($F(2,73) = 6.01$, $p = 0.00$), nonword ($F(2,73) = 2.81$, $p = 0.07$), and WS ($F(2,73) = 4.83$, $p = 0.01$) tests.

Table 3 Observed Means (M_{ob})Adjusted Means (M_{adj}) and Standardised Deviations (*SD*) for Scores on the Pretest and Post Test Spelling of Regular Word, Exception Word, and Nonword Tests, the Waddington Spelling Test, and Post Test Scores of the South Australian Spelling Test (n=76).

Class		Spelling Regular Words			Spelling Exception Words			Spelling Nonwords			Waddington Spelling Test			South Australian Spelling		
		M_{ob}	M_{adj}	*SD*	M_{ob}	M_{adj}	*SD*	M_{ob}	M_{adj}	*SD*	M_{ob}	M_{adj}	*SD*	M_{ob}	M_{adj}	*SD*
Phoneme	Pre	15.57		4.78	10.32		5.47	13.11		3.60	49.82		13.91			
Condition	Post	16.04	15.25	3.75	10.68	9.94	5.27	13.68	12.81	4.37	53.04	49.67	12.31	32.29	30.90	6.34
Grapheme	Pre	20.42		4.71	6.87		4.74	10.48		5.07	38.26		16.16			
Condition	Post	14.35	16.02	3.87	8.39	10.77	4.35	12.09	13.42	4.63	44.39	51.45	15.54	29.70	32.75	6.43
Contiguous	Pre	15.20		4.80	12.08		5.54	13.08		4.62	50.28		15.63			
Condition	Post	16.84	15.95	3.27	11.44	9.81	4.64	13.60	13.13	3.69	53.32	49.64	15.72	34.12	32.45	6.64

Note: For each of the spelling tests the score was calculated on the number of correct responses.

These differences indicated, in each case, superiority for class 3 (the Contiguous intervention condition) over the other two classes. Given that the classes in Study 1 differed significantly on all spelling measures used at pretest, the outcomes of these posttest analyses should be viewed as tentative and were included for exploratory purposes.

Assumptions for Covariance Analysis.

With internal consistency reliabilities over 0.80 for scores on the exception, regular, and non-words spelling tests, and a KR-20 reliability estimate of 0.95 for the WS test (respectively), pretest scores on these measures were considered to be adequately reliable to use as covariates. Tests for heterogeneity of regression hyperplanes across the three cells of the design were non-significant in all multivariate, univariate, and stepdown analyses (all $ps > 0.10$), indicating that the use of the pooled within-cells regression coefficients to adjust cell means was tenable.

The multivariate association between combined pretest and composite posttest scores on the five measures was significant ($V = 1.50$, approximate $F(20,272) = 8.18$, $p = 0.00$), with univariate regression analyses indicating strong relationships between combined pretest scores and achievement on the regular words ($F(4,69) = 72.24$, $p = 0.00$), exception words ($F(4,69) = 96.96$, $p = 0.00$), nonwords ($F(4,69) = 22.42$, $p = 0.00$), WS ($F(4,69) = 288.82$, $p = 0.00$) and SAST ($F(4,69) = 102.47$, $p = 0.00$) tests. This indicates that the use of the combined pretests as covariates produced a significant reduction in posttest error variance.

Outcomes.

Observed means, adjusted means, and standardised deviations for scores on the five posttests were also shown in Table 3. Based on the Pillai-Bartlett criterion, there was no significant effect for condition on combined posttest scores ($V = 0.19$, approximate $F(10,132) = 1.42$, $p = 0.18$). Thus, there were no significant differences across conditions on the spelling posttests.

6. Discussion

The specific aim of the research was to examine the effect of three different interventions (Phoneme, Grapheme, and Contiguous) on students' reading and spelling skills. Four measures were used to assess reading skills (the regular word, and nonwords tests, the listening comprehension test, and the Waddington reading test). Five measures were used to assess spelling skills (the regular word, exception word, and nonwords tests, the Waddington Spelling test, and the South Australian Spelling test).

A repeated measures analysis of variance indicated that in general, the students significantly improved from the pretest to the posttest, except on the reading of regular words and on the spelling of exception words. As indicated, it is possible that the nonsignificant change on the regular words test reflects a difference in the difficulty levels of the pre- and posttests (see section entitled Test construction). A similar explanation could be offered for the nonsignificant change observed on the spelling of exception words. The discrepancies in the difficulty levels of the pretests and posttests were addressed prior to the conduct of Study 2. Despite these discrepancies in Study 1, however, the students' performance on these words did improve marginally. When all the tests were taken into consideration, the general effect of the intervention was positive for the students.

For the tests on the major aims of the research, significant differences between the three experimental conditions were obtained on three of the five reading tests (the regular and exception reading tests, and the listening comprehension test) suggesting the superiority of the Phoneme intervention over the Grapheme intervention. The pattern of results across the three measures also suggested the superiority of the Phoneme intervention over the Contiguous approach, although these differences did not reach significance. There were no apparent differences between the Grapheme and Contiguous intervention groups, and no significant differences between any of the conditions on the five spelling tests.

These results suggested that the Phoneme intervention might have been superior to the Grapheme and Contiguous interventions for instruction in grapheme-phoneme relationships, but only in the area of reading. In this area, the effect was obtained on regular words. A significant improvement in reading exception words and listening comprehension by the Phoneme intervention was not maintained when dissociated from the main effect of reading regular words. This indicated that the phoneme intervention might have the potential to improve students' ability to decode, recognise and comprehend words in a way that cannot be differentiated without further research.

7. Critique and Directions for Study 2

The measures of pretest equivalence indicated that the three intervention groups were significantly different prior to the intervention. Specifically, the results indicated that the Contiguous intervention was significantly superior to the other two classes in their achievement levels on the pretests. Care was taken in Study 2 to ensure that pretest equivalence was maintained between the three intervention groups. As logistical factors prevented the random assignment of students to the interventions, the researcher was reliant on the pre-existing constitution of the groups being equivalent at the time of pretest.

The lack of pretest equivalence between the intervention groups detracted from the conclusion that the Phoneme intervention was superior to the Grapheme and Contiguous approaches. The significant pretest differences underlined the lack of random assignment of students to the conditions and that they were not matched according to ability.

Informal observation of the students during Study 1 provided useful feedback that was then used in the design of Study 2. The second exercise in particular was very demanding for the students. Students found it difficult to fully analyse words into their component grapheme- phoneme units. Sometimes they would focus on the number of syllables in the word, and at other times, they would split words into their onset and rime and some individuals chose to split words into antibody and coda. This became evident by the number of sounds that they heard in a word, and also the responses they gave during discussion time in the lessons. The students found it difficult to count the number of sounds (ie. phonemes) in a word, even a short monosyllabic word.

The worksheets in Study 2 provided the students with a task analysis that clearly illustrated the way to divide words into syllables, onset/rime and phonemes. It was anticipated that these additional activities would enhance the effectiveness of the interventions.

The exercises and the level of difficulty of the tests in Study 1 were modified in Study 2 to obtain a more accurate assessment of the children's performances.

The total number of students in the research was 76 and of this sample 16 were students for whom English was a second language (ESL). When the data were analysed with the ESL/non ESL separation treated as an independent variable the results indicated a lack of significant difference between the two subpopulations. Consequently, the inclusion of both ESL and non-ESL students was accepted in Study 2.

The evidence from this study suggests that, although the Phoneme intervention produced superior results on some reading tests, all three interventions produced significant pre-posttest gains in students' reading and spelling skills. In addition, the results suggested that instruction in the presentation of variant sound-letter correspondences might be more effective than the traditional contiguous letter-sound correspondences proposed by Adams, Byrne et al., and Bloomfield (e.g., Adams, 1990; Byrne, et al., 1996; Bloomfield et al., 1961). It might also be more effective than instruction in the variant letter-sound correspondences (i.e., the Grapheme intervention) proposed by Spalding and Spalding (1969).

The research was replicated in study 2 with the proposed modifications in procedures and test construction to further verify the effectiveness of the different interventions on the dependent reading and spelling variables. The expectation was that the evidence from Study 1 would be confirmed in Study 2. The researcher anticipated that the strategy of instructing children in the manner of phonemic awareness characterised in the Phoneme intervention would once again be confirmed. This would have demonstrated that teaching children to listen to the constituent sounds in words would lead to their greater development and acquisition of literacy skills irrespective of the orthographic elements of the language. On the other hand, if Study 2 indicated that the Contiguous intervention was significantly better than the Phoneme intervention, this would indicate that the orthographic and graphemic elements of the language were equally important as the phonemic elements. Further, it would indicate a combination of phonemic and graphemic elements would have an optimum effect in the instruction of letter-sound correspondences.

Chapter Eight STUDY 2

1. Aims of the Research

The aim of Study 2 was to replicate an improved and modified version of Study 1 and to assess the effects of the three different interventions on grade 2 students' ability to read and spell, regular words, exception words, and non-words, as well as normed reading/spelling and listening comprehension tests.

2. Research Questions

The major research questions addressed are the same as in Study 1 and were:

1) Were the concurrent Grapheme or Phoneme interventions more beneficial than the contiguous successive intervention for improving reading/spelling and listening comprehension skills?
2) Did the Grapheme and Phoneme interventions differ in their effects on these dependent variables?
3) Did the pattern of effects for the three interventions vary across the different measures of reading and spelling skills (eg., regular words, exception words, non-words, and listening comprehension tests)?

3. Method

I. Participants

The sample for Study 2 consisted of 81 children from three grade two classes in a denominational primary school on the lower North shore of Sydney where the socio-economic status was high. Written consent was obtained from the parents of all the children and approval to conduct the project had been successfully obtained from the Catholic Education Office and the University ethics committee. The experimenter conducted all the instruction during the interventions and the teachers were free to come and go from their classrooms.

The age range of the children was from 6 years to 8 years 5 months with M = 7 years 1 month and SD = 4.70 months. There were 37 boys and 44 girls. Data for all of the children was accepted in the final statistical analysis except in a few instances on the attitudinal survey where data was missing.

Research by Prior (1994) has indicated that grade 2 students have reached a reliable and stable level of reading and spelling performance. However, grade two children were observed in Study 1 to require further training in the development of phonemic awareness. In particular, most grade 2 children, had difficulty segmenting words into phonemes, and benefited from clear instruction in differentiating syllables, onset/rime units, individual phonemes and sound groups.

II. General Overview of the Program

i) Interventions

The experimental stimuli and items selected for the interventions in Study 2 were identical to those in Study 1. The modifications to Study 1 implemented in Study 2 only related to procedures and test construction.

ii) Design of the Instruction Program

The interventions were designed for student-centred teaching where the children were encouraged to engage in discovery learning. In each lesson, the children were given four tasks, except for the first two lessons where they were introduced to the first two tasks. The work sheets for each of the interventions consisted of the same exercises and instructions, and only differed in the selection of words introduced with each lesson. The duration of the intervention was 10 weeks, and consisted of two half-hour lessons per week.

The first and most important task required the children to sort words according to a defining characteristic, the sound of the letters underlined in each of a group of approximately twelve words. The words were scripted onto separate cards. The following instructions were given to all the students for the first four lessons:-

Please work with your partner in this lesson.

You have a set of cards with words on them.

Please sort the words into different piles.

Do it this way: -

1. *Take a card and say the word slowly. (Stretch it out)*
2. *Listen carefully to the sounds in the word.*
3. *One sound on each card is underlined.*
4. *Listen carefully to the sounds underlined.*
5. *Put down the card that you have worked on.*
6. *Take another card. Look at the underlined letter(s).*
7. *Do they have the same sound as the first card?*
8. *Write out the words in your 2nd pile in column 2. (Continue with your other piles in columns 3 and 4).*
9. *If the underlined sound is the same, put the card on top of the other card. If the underlined sound is different, make a new pile.*

10. *Now write out the words on the cards in your first pile in column (1) in the box below. Check that all the underlined sounds are the same.*

Instruction Box 1.

The students were given cards to sort according to the above instructions. On the basis of the pretests, the students were seated in pairs where a competent reader assisted a poorer reader. The children were told that they should help one another and that copying each other's work was allowed. The students were also encouraged to ask the experimenter for the correct pronunciation or the meaning of any of the words in the lesson. The first pair of students to complete their sort of the experimental stimuli was asked, on a voluntary basis, to present their sort to the rest of the class. After a few weeks this was regulated so that all the children had an opportunity to make a presentation of their sort to the class. The experimenter checked their sort before they made their presentation to minimise embarrassment. It was observed in both Study 1 and Study 2 that this opportunity acted as a reward for most students.

During the first few lessons the experimenter modelled the instructions, and then the children were encouraged to sort their words. Identical instructions, modelling and peer collaboration were implemented in each of the interventions. The initial instructions were abbreviated after four lessons, for the same reason as though in study 1. The abbreviated form of the instructions read as follows: -

Sort the cards by listening to the sounds of the underlined letters. If the sounds are the same put them together. If the sounds are different, make a new pile or put them in the miscellaneous column. Do the letters show you the sounds? When you hear the sound, will you know the letter?

Instruction Box 2.

The second exercise required the students to count the number of syllables in the words. The instructions for this exercise read as follows:

Counting syllables in words.

1. *Look at the words in the first column.*
2. *Say the first word slowly.*
3. *Clap each part of the word as you say it slowly.*
4. *How many times did you clap............?*
5. *How many syllables do you hear.......?*
6. *In the box below, start with the fourth word and write the syllables of each word into the columns.*

Instruction Box 3.

This second exercise was included in the first eight lessons and appeared as part of the third and fourth exercises for the remaining lessons, since the third and fourth exercises also required the students to count the syllables in words.

The third exercise instructed the students to listen to the onset and rime in syllables. The first two words in the exercise table were analysed into onset and rime as illustrations. The instructions read:-

1. *Look at the third word in the first column.*
2. *From the above exercise how many syllables does the third word have?*
3. *Say the first syllable of this word slowly.*
4. *Do you hear the beginning sound(s)? This is the onset.*
5. *Do you hear the end sound(s)? This is the rime.*
6. *In the box below write the beginning sound(s) of each syllable in the onset box. Write the end sound(s) of each syllable in the rime box.*

Instruction Box 4.

This exercise commenced at the fourth lesson and then continued for the remainder of the intervention.

The fourth exercise instructed the children to fully analyse each word into its constituent sounds. Once again the first two words were analysed as examples for the remainder of the exercise. The instructions were as follows: -

Now we will listen to all the sounds in a word.

(1) Divide the word into syllables.

(2) Say the syllable slowly.

(3) Record each sound of each syllable in the boxes provided.

Instruction Box 5.

This exercise commenced at the eighth lesson and continued for the remainder of the intervention.

The fifth exercise provided the students with a list of consonants and consonant blends on the one hand, and a group of rimes to which they could add the consonantal onset, on the other. The children were rewarded with a tally and a stamp for the number of words they made from the onsets and rimes. The students were simply given the following question.

Can you make other words with these bits? (You may use the letters from below the box).

Instruction Box 6.

The material for this exercise was partly developed from the research of Stanback (1991 & 1992) who has compiled lists of rime patterns from a sample of 17,602 frequency-based words.

This exercise appeared as the fourth exercise in all the lessons except for the first two, and facilitated the process of blending sounds into words and reconstructing words from a given set of onsets and rimes.

iii) Rewards

The reward regimen for Study 2 was identical to Study 1.

iv) Tests and Test Construction

Waddington (1988) Diagnostic Reading and Spelling Tests: The Waddington (1988) Reading (WR) test was administered as a pretest. An alternate form of this test was constructed by substituting the original items with carefully selected items of similar content for the posttest. The words were matched according to frequency from Carroll et al's (1971) list and the sentences were matched for number of words and difficulty of concept. Other criteria specified in Waddington's (1988) manual were also adhered to.

To assess the parallel forms reliability of the two alternative versions of the test, both forms were trialed with 64 grade 3 children who were not involved in the intervention study. The two forms were administered under standardised conditions, across two days. The results indicated a very high parallel forms reliability for the two tests of (.98) (see Table 4 p 124).

The *Coltheart Reading test:* contained 90 items that were randomly presented to the children on flash cards. The 90 items consisted of 30 regular words, 30 exception words and 30 nonwords. Coltheart, M and Leahy (1996) have normed this test on 420 Australian students. (For details of tests see Appendix C.)

Reading Posttest: As indicated in Study 1, a 90-word parallel form of the Coltheart, M and Leahy (1996) test was also developed to minimise test-retest confounding effects. The procedures used in this development are described in Study 1. The two versions of this test were also trialed with the group of non-participating Grade 3 students (n=64) to determine their parallel forms reliability. These results indicated a high correlation (.89) between the Coltheart, M and Leahy regular word pretest and the constructed regular word posttest (see Table 4). The parallel forms reliability estimate for the exception word section was .96 (see Table 4). Unlike in Study 1, the nonwords (30) section of the reading posttest also differed from that used in the pretest. The parallel form of this section was constructed by varying the consonants in the original test. The parallel forms reliability of the non-word subtest was also moderately high (.81) (see Table 4). (For word lists of tests see Appendix C.)

The Listening Comprehension Test: This test was the same as that used in Study 1.

Spelling tests: The same construction procedures as those used in Study 1 were performed to create a parallel form of this test. Thus, words were selected from *The American Heritage: Word Frequency list* by Carroll, et al. (1971). For both the pre- and posttest spelling tests, twenty words were randomly selected from the 100-550 most frequent words in Carroll et al.'s (1971) rank order list. The parallel forms reliability on the regular words was .89, exception words .90, and non-words .97 (see Table 4).

Waddington (1988) Spelling (WS) Test. The WS test was administered as a pretest. This test is normed on Australian students. A variant Waddington Spelling posttest was constructed. It consisted of words that were matched with the original test on the following criteria: -

- on frequency according to *The American Heritage: Word frequency list* by Carroll, et al. (1971)
- on number of letters
- on number of syllables
- on type of phoneme to grapheme correspondence, and other specified criteria outlined in Waddington's (1988) manual of Diagnostic reading and spelling tests

The parallel forms reliability between the Waddington Spelling pretest and the variant Waddington spelling posttest was .97 when trialed on two classes of grade 3 children (n=64) (see Table 4). (To cite a sample of the test see Appendix C.)

The only tests to be individually administered were the reading tests (i.e., 90 words) and the listening comprehension test. Together these two tests occupied about fifteen minutes of the student's time.

Table 4 Reliability Analysis of the Dependent Measures

Dependent Measure	Parallel	Cronbach's α	
	r_{xx}	Pretest	Post
Reading Regular Word	0.89	0.89	0.9
Reading Exception Word	0.96	0.83	0.8
Reading Non-Word Pretest	0.81	0.91	0.91
Spelling Regular Word	0.92	0.91	0.9
Spelling Exception Word	0.90	0.92	0.9
Spelling NonWord	0.91	0.86	0.8
Waddington Reading	0.98	0.88	0.87
Waddington Spelling	0.97	0.96	0.9

v) *Attitudinal Survey*

Attitudinal Survey: With each battery of tests the same attitudinal survey was administered (see Appendix C for items included in this survery). The survey consisted of 28 items and contained four underlying constructs. The first three constructs included questions relating to the difficulty, the value, and anxiety associated with reading (Power, Hurt, and Dunathan, 1981, Zbornik & Wallbrown, 1991) and the fourth construct related to the locus of control of reading acquisition (Blaha & Chomin, 1982). This last construct asked students to reflect on and evaluate the contribution their own effort made to their reading acquisition.

4. Results Study 2

To compare posttest scores for students in the Phoneme, Grapheme, and Contiguous intervention conditions, scores were again grouped into two conceptual sets (reading and spelling achievement), and separate MANCOVAs performed on scores in the two sets. In each case, corresponding pretest measures were used as concomitant variables. All other procedures used were the same as those in Study 1.

Assumptions for Uni-Multivariate Analysis of Variance.

Screening procedures for the three sets of scores suggested adequate conformity to univariate and multivariate analysis of variance assumptions. Mahalanobis distances, calculated separately for each of the three cells of the design, indicated no multivariate or univariate outliers (*ps* > 0.05), and all tests for heterogeneity of variance and dispersion matrices were nonsignificant (*ps* > 0.05). Assumptions of univariate and multivariate normality were judged to be tenable.

I. Reading Outcomes

Overall Pretest-Posttest Gains

To assess whether students' reading skills increased generally from pre to posttest across all conditions, scores on the five reading measures were subjected to a repeated measures analysis of variance (ANOVA). This indicated a significant multivariate difference between scores on the pre- and posttests ($V = 0.79$, $F(5,73) = 54.42$, $p < 0.001$). Univariate ANOVAs indicated significant increases from pretest to posttest on all of the dependent measures ($Fs(1,77) \geq 22.16$, $ps < 0.001$, $\eta^2 \geq 0.22$) and that the interventions had contributed positively to the literacy development of the students.

Pretest Equivalence.

Mean pretest scores on the tests for regular words, exception words, nonwords, LC and the WR are shown in Table 5. To determine whether pretest scores differed significantly across the three experimental conditions, a one-way MANOVA was performed for pretest scores on the five tests. This indicated no significant multivariate effect for condition ($V = 0.15$, approximate $F(10,144) = 1.21$, $p = 0.29$). Univariate tests on the regular word, non-word, WR, and LC measures were also nonsignificant (all *ps* > 0.10).

Assumptions for Covariance Analysis.

With internal consistency reliabilities over .83 for scores on the exception word, regular word, and non-word tests (see Table 4), and a KR-20 reliability estimate of 0.97 for the WR reading test, pretest scores on these measures were considered to be adequately reliable to use as covariates. Tests for heterogeneity of regression hyperplanes across the three cells of the design were nonsignificant in all multivariate, univariate, and stepdown analyses (all *ps* > 0.10), indicating that use of the pooled within-cells regression coefficients to adjust cell means was tenable.

The multivariate association between combined pretest and composite posttest scores on the five measures was significant ($V = 1.62$, approximate $F(25,350) = 6.73$, $p < 0.001$), with univariate regression analyses indicating strong relationships between combined pretest scores and achievement on the regular words ($F(5,70) = 57.74$, $p < 0.001$), exception words ($F(5,70) = 95.11$, $p < 0.001$), nonwords ($F(5,70) = 46.90$, $p < 0.001$), WR ($F(5,70) = 16.88$, $p < 0.001$) and LC ($F(5,70) = 12.99$, $p < 0.001$) tests. Thus, use of the combined pretests as covariates produced a significant reduction in posttest error variance.

Reading Outcomes.

Observed means, adjusted means, and standard deviations for scores on the five posttests are also shown in Table 5. Based on the Pillai-Bartlett criterion, the main effect for condition on combined posttest scores approached significance at the 0.05 level ($V = 0.22$, approximate $F(10,134) = 1.66$, $p = 0.10$). Since a significant degree of overlapping variance was found between scores on the set of posttest measures (Bartlett's $\chi^2(10) = 42.82$, $p < 0.001$), both univariate and stepdown *F*s were used to assess the effects of the conditions on the five measures separately. The order of entry was the same as that used in Study 1.

Table 5 Observed Means (M_{ob}) Adjusted Means (M_{adj}) and Standard Deviations (*SD*) for Scores on the Pre- and Posttest Reading of Regular Word, Exception Word, and Non-word Tests, the Waddington Reading Test and Listening Comprehension Test (*n*=81)

Class		Reading Regular Words			Reading Exception Words			Reading NonWords			Waddington Reading Test			Listening Comprehension		
		M_{ob}	M_{adj}	*SD*	M_{ob}	M_{adj}	*SD*	M_{ob}	M_{adj}	*SD*	M_{ob}	M_{adj}	*SD*	M_{ob}	M_{adj}	*SD*
Phoneme	Pre	22.07		7.55	14.67		5.41	17.19		8.54	38.56		5.19	4.70		1.81
Condition	Post	22.96	22.93	7.08	18.30	18.14	6.70	21.00	21.09	8.32	41.30	40.68	5.19	6.85	6.60	1.77
Grapheme	Pre	22.00		6.25	14.56		3.90	16.37		7.32	37.22		5.29	3.70		1.61
Condition	Post	23.37	23.34	5.19	17.96	18.01	5.60	19.30	19.61	7.10	40.67	41.09	6.02	5.74	6.01	2.28
Contiguous	Pre	22.33		5.58	13.97		4.65	17.92		6.52	37.83		6.62	4.58		2.20
Condition	Post	25.13	25.13	4.65	18.25	18.36	5.43	22.42	22.00	5.18	40.21	40.40	7.65	6.21	6.18	1.91

Note: For each of the reading tests the score was calculated on the number of correct responses. For the listening comprehension test the score was calculated at a grade level (at least 3 out of 5 correct answers to comprehension questions)

The univariate ANCOVAs indicated a significant effect on regular words ($F(2,70) = 4.56, p = 0.01$, partial $\eta^2 = 0.12$) and a marginally significant effect on the nonwords ($F(2,70) = 2.69, p = 0.08$, $\eta^2 = 0.07$). All other univariate effects were nonsignificant (all $Fs(2,70) < 1.02$, $ps > 0.36$). The effect on the nonwords was also not significant at stepdown (stepdown $F(2,68) = 1.99$, p = 0.16) indicating that the univariate effect found on this measure was already accounted for in its overlap with the regular word test. The pattern of adjusted means for the regular words test is shown in Figure 7. The significant effect favoured the Contiguous intervention, while the lowest scores were recorded in the Phoneme intervention. Bryant-Paulson *qs* indicated that on each dependent measure, the Contiguous intervention students significantly outperformed those in Phoneme intervention condition ($q = 5.66$, $p < 0.05$). However, there were no significant differences between the Phoneme and Grapheme or between the Grapheme and Contiguous interventions, although the latter difference did approach significance at the 0.05 level ($q = 3.26$, $p < 0.10$).

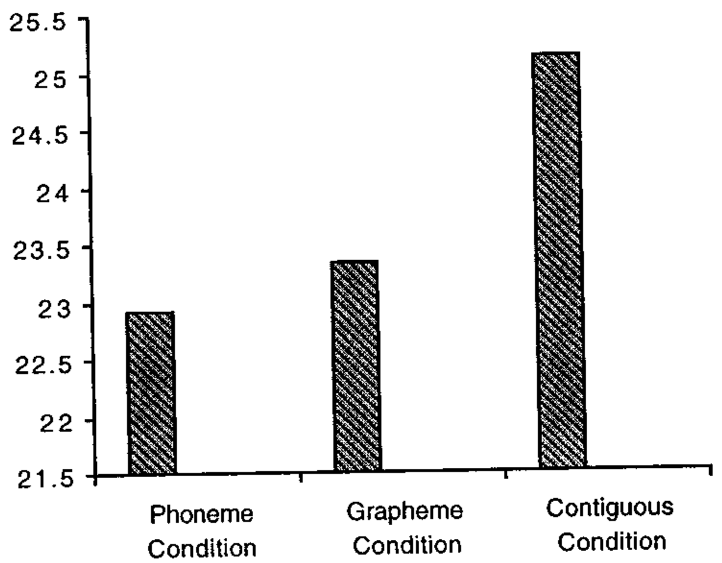

Figure 7 Adjusted Reading Posttest Means on the Regular Word Reading Test for Students in the Phoneme, Grapheme and Contiguous Intervention Conditions.

II. Spelling Outcomes

Overall Pretest-Posttest Gains

To assess whether students' spelling skills increased generally from pre- to posttest across all conditions, scores on the four reading measures for which a pretest was available were subjected to a repeated measures ANOVA. This indicated a significant multivariate difference between scores on the pre and posttests ($V = 0.95$, $F(4,74) = 370.73, p < 0.001$), while univariate ANOVAs indicated significant increases from pre- to posttest on all of the dependent measures ($Fs(1,77) \geq 259.58$, $ps < 0.001$, $\eta^2 \geq 0.36$).

Pretest Equivalence.

Mean pretest scores on the regular word, exception word, nonword and WS spelling tests are shown in Table 6. To determine whether pretest scores differed significantly across the three experimental conditions, a one-way MANOVA was performed for pretest scores on the four tests. This indicated a significant multivariate effect for condition ($V = 0.30$, approximate $F(8,146) = 3.24, p = 0.002$). Univariate tests indicated no significant univariate effects ($F(2,75) < 1.23, ps > 0.30$), however, the effect for WS was highly significant at stepdown ($F(2,72) = 12.84, p < 0.001$). To determine whether this was responsible for the significant multivariate effect, the WS pretest was removed and the MANOVA performed again. This analysis indicated no significant overall effect for class ($V = 0.05$, approximate $F(6,148) < 1$). Given that the pretest differences appeared to have resulted from differences on the WS pretest, data from this test was not used in the analysis as a covariate.

Assumptions for Covariance Analysis.

With internal consistency reliabilities over 0.83 (see Table 4) for scores on the tests of exception words, regular words, and non-words, and a KR-20 reliability estimate of 0.95 for the WS test, pretest scores on these measures were considered to be adequately reliable to use as covariates. Tests for heterogeneity of regression hyperplanes across the three cells of the design were nonsignificant in all multivariate, univariate, and stepdown analyses (all $ps > 0.10$), indicating that use of the pooled within-cells regression coefficients to adjusted cell means was tenable.

The multivariate association between combined pretest and composite posttest scores on the five measures was significant ($V = 1.13$, approximate ($F(9,216) = 14.53, p < 0.001$), with univariate regression analyses indicating strong relationships between combined pretest scores and achievement for the regular words ($F(3,72) = 52.17$, $p < 0.001$), exception words ($F(3,72) = 79.13, p < 0.001$), and nonwords ($F(3,72) = 31.37, p < 0.001$). This indicated that the use of the combined pretests as covariates produced a significant reduction in posttest error variance.

Spelling Outcomes.

Observed means, adjusted means, and standard deviations for scores on the four posttests are also shown in Table 6. Based on the Pillai-Bartlett criterion, the main effect for condition on combined posttest scores approached significance at the 0.05 level ($V = 0.24$, approximate $F(6,142) = 3.16$, $p = 0.01$). Since a significant degree of overlapping variance was found between scores on the set of posttest measures (Bartlett's $\chi^2(3) = 35.97$, $p < 0.001$), both univariate and stepdown *F*s were used to assess the effects of the conditions on the four measures separately. The order of entry was the same as that used in Study 1.

The univariate ANCOVAs indicated a significant effect on the exception words and non-words ($F(2,72) = 7.24$, $p = 0.001$, partial $\eta^2 = 0.17$; $F(2,72) = 5.87$, $p = 0.004$, $\eta^2 = 0.14$), but no significant difference on the regular words ($F(2,72) = 1.32$, $p = 0.27$).

The effects on the exception words and nonwords remained significant or marginally significant at stepdown (stepdown $F(2,71) = 5.80$, $p = 0.005$; stepdown $F(2,70) = 2.79$, $p = 0.07$). The pattern of adjusted means for the exception word and nonword tests is shown in Figures 8 and 9. As indicated, in both cases, the significant effect favoured the Contiguous intervention, while the lowest scores were recorded in the Grapheme intervention. Bryant-Paulson *q*s indicated that on the exception words measure, the Contiguous intervention students significantly outperformed those in both the Phoneme and Grapheme interventions ($q = 4.38$, $p < 0.05$; $q = 6.24$, $p < 0.05$, respectively). There was no significant difference between the latter two interventions. On the nonwords measure, the only significant difference was between the Contiguous and Grapheme interventions ($q = 5.28$, $p < 0.05$). The other two differences were not significant ($qs \leq 3.09$, $ps > 0.10$).

Table 6 Observed Means (M_{ob})Adjusted Means (M_{adj}) and Standard Deviations (*SD*) for Scores on the Pre- and Post Test Spelling of Regular Word, Exception Word, and Non-word Tests, the Waddington Spelling Test, and Post Test Scores of the South Australian Spelling Test (*n*=81).

Class		Spelling Regular Words			Spelling Exception Words			Spelling NonWords			Waddington Spelling Test		
		M_{ob}	M_{adj}	*SD*	M_{ob}	M_{adj}	*SD*	M_{ob}	M_{adj}	*SD*	M_{ob}	M_{adj}	*SD*
Phoneme	Pre	11.63		5.65	6.78		5.21	10.70		6.18	39.85		17.37
Condition	Post	14.30	14.28	5.06	10.26	10.37	5.72	13.56	13.38	4.79	45.04	45.00	15.11
Grapheme	Pre	11.81		4.76	7.07		4.69	10.52		3.95	37.11		13.36
Condition	Post	13.93	14.25	4.42	9.67	10.16	5.14	11.78	12.09	4.79	45.15	46.44	11.96
Contiguous	Pre	10.96		4.39	7.33		4.50	10.04		4.30	43.46		11.69
Condition	Post	14.58	14.27	3.87	12.08	11.49	5.14	14.17	14.02	4.44	46.46	45.20	12.70

Note: For each of the Spelling Tests the score was calculated on the number of correct responses.

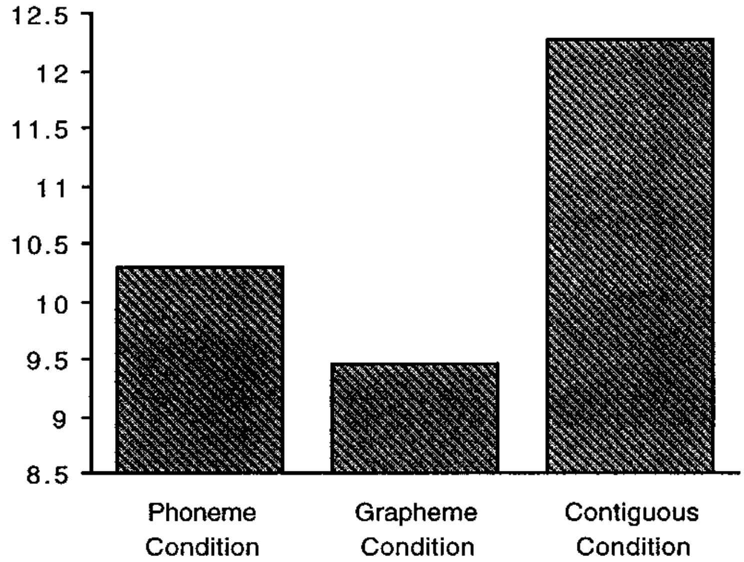

Figure 8 Adjusted Spelling Posttest Means on the Exception Word Test for Students in the Phoneme, Grapheme and Contiguous Intervention Conditions.

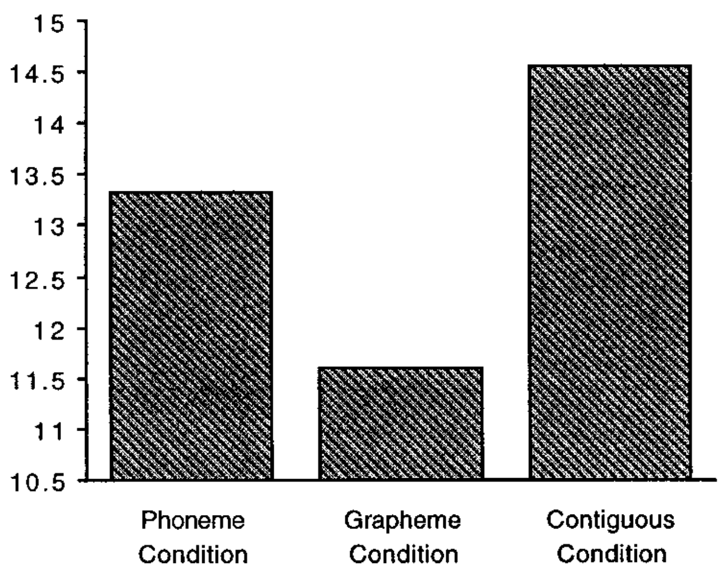

Figure 9 Adjusted Spelling Posttest Means on the Nonword Test for Students in the Phoneme, Grapheme and Contiguous Intervention Conditions.

Class	Attitude Pretest Group	n	Attitude Pretest *M*	Attitude Pretest *SD*	Attitude Posttest *M*	Attitude Posttest *SD*
Phoneme	Low	13	36.54	3.69	38.69	4.70
	Medium	8	44.00	1.60	44.38	9.18
	High	6	53.50	7.29	46.67	6.19
	Combined Phoneme Group	27	42.52	7.97	42.15	7.24
Grapheme	Low	7	37.43	2.99	42.00	5.29
	Medium	7	43.43	.98	43.57	7.23
	High	13	53.15	4.36	51.23	8.96
	Combined Grapheme Group	27	46.56	7.61	46.85	8.63
Contiguous	Low	12	39.17	2.44	36.92	4.29
	Medium	8	44.25	1.58	43.13	5.41
	High	4	53.50	4.04	51.00	5.72
	Combined Grapheme Group	24	43.25	5.75	41.33	7.04
Combined Attitude (Low)		32	37.72	3.25	38.75	4.92
Combined Attitude (Medium)		23	43.92	1.41	43.70	7.12
Combined Attitude (High)		23	53.30	4.97	50.00	7.82

Table 7 Means and Standard Deviations (*SD*) for Scores on the 28 Questions in the Attitude Survey.

III. Attitude Results

To determine whether students' attitudes differed across classes, a one-way analysis of covariance was performed. With internal consistency reliabilities over

0.80 for scores on this measure, pretest scores were considered to be adequately reliable to use as covariates. An ANOVA on attitude pretest scores also indicated no significant differences across classes at pretest ($F(2,74) = 1.69, p = 0.19$).

However, the test for the interaction effect of pretest and class indicated significant heterogeneity of regression slopes across the three cells of the design ($F(2,75) = 4.37, p = 0.016$). Subsequent tests for the relationship between pre- and posttest scores, performed separately for each of the designs, indicated that although the direction of the relationship did not differ across cells, the correlation was stronger in the Contiguous intervention than in the Grapheme and Phoneme interventions (*Rs*=0.72, 0.65, and 0.54, respectively).

As this indicated that use of the pooled within-cells regression coefficients to adjusted cell means would produce misleading results, an ANCOVA was not performed. Instead, the pretest scores were blocked into low, medium, and high scorers based on percentile ranks, and pretest was incorporated as a second factor in an ANOVA on attitude posttest scores, producing a 3 (class) by 3 (attitude pretest) factorial design.

Observed means and standard deviations for scores on the four posttests are also shown in Table 7 by attitude pretest and class. The ANOVA on posttest scores indicated a significant main effect for attitude pretest ($F(2,69) = 14.19$, $p = 0.00$, partial $\eta^2 = 0.29$), but no significant main effect for class ($F(2,69) < 1$) and no significant class by attitude pretest interaction ($F(4,69) < 1$). Thus, there was no significant effect of the interventions, either across the full sample or for low, medium, and high attitude students individually.

5. Discussion

The specific aim of the research was to examine the effect of three different interventions (Phoneme, Grapheme, and Contiguous) on the students' reading and spelling skills. Four measures were used to assess reading skills (the regular word, and nonword tests, the listening comprehension test, and the normed Waddington Reading test). Four measures were used to assess spelling skills (the regular word, exception word, and nonword tests, and the normed Waddington Spelling test).

A repeated measures analysis of variance indicated that in general, the students significantly improved from the pretest to posttest. This improvement in reading and spelling could be partly attributable to the direct instruction that the students received in phonemic and phonological awareness as well as other factors like normal maturation. A more precise assessment of other influences on development is not possible, as the experiment did not contain an alternative control group by which to compare these results.

For the tests on the major aims of the research, significant differences between the three experimental conditions were obtained on one of the five reading tests (the regular word test) suggesting the superiority of the Contiguous intervention over the Grapheme and Phoneme interventions. Similarly, significant differences between the three experimental conditions were obtained on two of the five spelling tests (the exception and nonword tests) again suggesting the superiority of the Contiguous intervention over the Grapheme and Phoneme interventions.

These results indicated that the Contiguous intervention may have been superior to the Grapheme and Phoneme interventions for instruction in grapheme-phoneme relationships in both reading and spelling.

Chapter Nine GENERAL DISCUSSION AND CONCLUSIONS

1. Study 1

There were several differences between Study 1 and Study 2. Study 1 took place in a public school where teaching instruction was more heterogeneous and diverse than in the denominational school used for Study 2. The teacher of the Phoneme intervention class in Study 1 was very committed to direct instruction in phonemic awareness whereas the teachers of the Grapheme and Contiguous intervention classes were more committed to a top-down approach. This difference might have accounted for the significantly better performance of the Phoneme intervention class on the reading of regular words, exception words and in listening comprehension. This advantage was attained even though the Contiguous intervention class was more advanced than the other two classes at the time of pretesting. The benefit of extensive direct instruction in phonemic awareness in combination with whole word instruction compared with relatively less phonemic awareness instruction has been established by previous research (Bryant and Bradley, 1985; Berninger and Abbott, 1994; Berninger et al., 1998, 2000; Bruck et al., 1998; Deavers and Brown, 1997; Foorman and Francis, 1994; Torgesen et al., 1999; Uhry and Shepherd, 1997; Vandervelden and Siegel, 1997) (for further information see p. 95). The results of this research have indicated that the more time and attention devoted to direct instruction in phonemic and phonological awareness, the greater the improvement in reading performance.

The other factors that might have contributed to the difference between the patterns of results attained in Study 1 compared to Study 2 were that the spelling tests lacked equivalence in level of difficulty and that the procedural instructions lacked clarity in Study 1.

The other indication that Study 1 was not as definitive in its results as Study 2 was that the benefits of Study 1 related to reading and listening comprehension. Previous research has indicated that phonemic awareness contributes more to spelling than to reading (Foorman, 1994 and Lundberg, et al., 1988) and that spelling development predicts future reading development more than reading development predicts future spelling development (Kirtley et al., 1989). In Study 2, spelling improvements were more evident than reading improvements indicating that the students grasped the alphabetic principle at a level that would normally translate into increased reading outcomes in the future.

The superior improvement of the Phoneme intervention in reading regular words and exception words, and listening comprehension skills also indicated that the instruction had contributed to both word recognition skills and comprehension skills in a way that would develop effective reading abilities (Aaron, 1989).

2. Study 2

The results of Study 2 indicated that the Contiguous intervention group in the homogeneous, eclectic but top down orientated denominational school attained a performance superior to the Phoneme and Grapheme intervention groups. The superior performance of the Contiguous class was significant in reading regular words, and in spelling exception words and nonwords. These results indicated that a contiguous presentation of orthographic and phonological information contributed to reading and spelling acquisition more than a presentation of either variant graphological information as in the Grapheme intervention or variant phonological information as in the Phoneme intervention.

The attitudinal survey indicated that there were no significant differences between the interventions. A precursory statistical analysis of the attitudinal data did not confirm the presence of separate factors and thus the survey was used as a general indicator of student conduct.

Previous research has indicated that variant grapheme-phoneme information does hurt literacy performance. Research has indicated that irregularities and inconsistencies with onsets, rime bodies, and homophones have detrimentally affected reading performance (Lukatela and Turvey, 1993; Rastle and Coltheart, 1999b; Treiman, Mullennix, et al., 1995). Besner and Stolz (1998) deliberately used pseudohomophones in their research to place strain on the phonological processing of print implying that grapho-phonological variance is harmful to the cognitive processing of literacy tasks.

On the other hand, the contiguous presentation of grapho-phonological information where the visual and auditory information is held constant has been found to contribute positively to the acquisition of literacy acquisition (Bowey and Hanson, 1994; Bryne, Fielding-Barnsley and Ashley, 1996; Goswami and Bryant, 1985; Treiman, Mullennix, et al., 1995). Furthermore, the Dual Route Cascaded Model (Coltheart et al., 1993; Coltheart et al., 2000) and the Connectionist Models (Seidenberg and McClelland, 1989; Plaut et al., 1996) are also based on the consistencies of frequently occurring patterns of grapheme-phoneme relationships irrespective of the regularity of those relationships. Consistency and regularity of grapheme-phoneme correspondences formed the basis of the Contiguous intervention. The Contiguous intervention presented sets of three exemplars of grapheme-phoneme correspondences irrespective of whether those correspondences were the regular, official, major, or the minor, inconsistent grapheme-phoneme correspondences analysed by Venezky (1970 and learning took place on the basis of the visual and auditory information occurring contiguously. The results of this research are best accounted for by the Connection-Forming Process of Ehri and Wilce (1985) where learning takes place when orthographic, phonological and other linguistic information are amalgamated and presented contiguously. The Connection-Forming Process unites the common factors implicit in phonemic and phonological awareness (Ehri and Robbins, 1992; Ehri, 1995). The strength of phonological awareness is that the rime units and rime families contain consistent and contiguous grapho-phonological information. However, the contiguous presentation of grapho-phonological information also occurs at the phonemic level and has led to the establishment of the alphabetic principle (Treiman, Mullennix, et al., 1995; Bryne, Fielding-Barnsley and Ashley, 1996).

3. Personal Interpretation of Meaning

Research by Mayer (1997) on multimedia learning has indicated that the contiguous presentation of visual and verbal information significantly contributes to subjects' resolution of transfer problems. The analogy hypothesis of Goswami and Bryant (1990, see also Stanback, 1991) supports the contiguous presentation of phonological units and the connection-forming process of Ehri and Wilce, (1987) supports the contiguous presentation of phonological and phonemic units. On the other hand, Muter et al. (1998), Bryne et al. (1996) Rastle and Coltheart (1999b) support the contiguous, regular and transparent presentation of phonemic information. That is, the grasp of frequent spelling patterns has been demonstrated to occur at both the fine and coarse grain levels, however, the effectiveness of rime families is limited in scope to the members of that family while the scope of effectiveness for phonemes goes deeper and broader. For example, the silent 'e' marker embraces many monosyllabic and polysyllabic rime families including the long 'o' sound in O-E words, the long 'u' sound in U-E words, the long 'a' sound in A-E words etc. The capacity of the silent 'e' marker to indicate a long vowel sound rather than a short vowel sound has been acknowledged by many psychometric and pedagogical models, and exists in a large body of words (Coltheart et al., 1993; Lamond and Whiting, 1992; Spalding and Spalding, 1969).

Almost every letter of the English alphabet has been used as a silent marker either for etymological reasons (e.g., the 'h' in the digraphs 'ch', 'rh', 'ph', and 'gh' to indicate Greek origin) or for various morphological reasons (e.g., the doubling of letters for grammatical purposes where the graphemic information is duplicated but the phonemic information is not duplicated for example, the /b/ sound in DUBBING, or to indicate the preservation of a letter (b) that is silent in one form but sounded in another as in BOMB/BOMBARD etc.) (Henderson and Templeton, 1986; Henry, 1988; Scholfield, 1994). The silent letters 'gh' and 'g' are also used in a manner similar to the silent 'e' in both the IGHT words and IGM in the hermit word PARADIGM to indicate the long /i/ sound. Hornsby and Shear (1974) introduced the concept of the wicked witch 'w' to indicate the frequently inconsistent behaviour of the letter 'w' on subsequent vowel sounds (e.g., the short /o/ sound in WAS and the /er/ sound in WORK etc.). English orthography has dictated the characteristics of the letter-sound correspondences as much as the evolving phonology. Venezky (1970) characterised the English script as morpho-phonemic because of the preservation of these morphological, grammatical, etymological and semantic carrying elements in the written language. The evidence of this research has indicated that when this information is presented contiguously in sets of exemplars then learning takes place more than when this information is presented in isolation and non-contiguously, and thus contributing to grapho-phonological variance.

The Unconventional theory of speech postulated that linguistic orthography is culturally transmitted and phonology is biologically determined (Liberman, 1994; see also de Saussure, 1972). The English language has assimilated approximately 43 different sounds and has orthographically accommodated their representation into their alphabetic script while at the same time preserving etymological, diachronic and synchronic information (de Saussure, 1972; Seidenberg and McClelland, 1989). Consequently, the English writing system has developed a deep and rich literary environment.

Research by the Dual Route Cascaded modellers has verified that monosyllabic words are processed serially and completely whereas research by the Connectionist modellers relies on there being a parallel and analogical processing of whole words (Coltheart et al., 1993, 2000; Seidenberg and McClelland, 1989; Rastle and Coltheart, 1999b). In effect both the DRC and the Connectionist models process whole words before a response is made but the DRC model retains a phonemic and serial level of processing that reflects the alphabetic character of the English writing system and also the deep and frequently occurring patterns and behaviours of phonemes.

4. Importance of Findings

The suggested pedagogical implication of this research is that literacy instruction should include sets of exemplars of different orthographic, morphological, grammatical and etymological information to reinforce the connection between graphemic and phonemic information. When grade 2 children are given words that contain letter-sound correspondences that present consistent visual and auditory information learning will take place at a significantly improved rate than when they are presented with isolated, variant and conflicting information. It is recommended that children be presented with sets of words or sublexical units that contain orthographic and phonological similarities rather than differences and that this will enable children to learn the underlying frequently occurring spelling patterns in the English script. This research also recommends that consideration be given to the visual and auditory content of linguistic information and that this information be presented contiguously and consistently.

5. Limitations of the Studies

Any inferences drawn from these studies are limited by the absence of a null intervention control group and the experiment having a quasi-experimental design. The incorporation of a control group would have established the effectiveness of the interventions compared to normal developmental progress and maturation. The design of the experiment also lacked a full randomization of the student body. Although the interventions were randomly assigned to the three grade 2 classes the students were not randomly assigned to the different classes for the purpose of the studies. The results of the first study were also limited by faults in test construction and validation, however the tests in the second study were carefully validated and tested for reliability. Any inferences from the studies should also be made with caution for children in classes other than for grade 2 since the experiment has not been applied to a variety of age groups. In order to ensure equity all participants were given instruction in phonemic and phonological awareness, and also the alphabetic principle. The inclusion of a null intervention control group would have meant some children would not have received instruction in these crucial skills.

6. Directions for Future Research

Future research could establish if these results were specifically indicative of grade 2 children only or if older children would benefit from the contiguous or the variant presentation of grapho-phonological information at the phonemic level. Seymour et al's (1999) research indicated that younger children developed epilinguistic abilities where they could globally analyse letter-sound relationships and later developed metalinguistic abilities where they could consciously manipulate this information. The presentation of variant phonological and orthographic information requires metalinguistic abilities that can compare and contrast orthographic information that has been formed by diachronic, synchronic, morphological and etymological pressures. Future research could determine the stage at which children benefit from a metalinguistic awareness of phonological and orthographic variance or whether a contiguous presentation remains the most facilitative of literacy development at all stages.

Further quantitative and qualitative research could also determine if there is anxiety associated with phonological or orthographic variance and what metacognitive strategies are adopted when processing print in this context.

7. Conclusion

This research supports the successive and contiguous presentation of official letter-sound relationships in preference to the concurrent presentation of either phonological or orthographic variance (Adams, 1990; Brand, 1994; Spalding and Spalding, 1969). The set for regularity was found to be more facilitative of literacy acquisition than the set for diversity that may have been partially inhibitive (Beck and McCaslin, 1977). This research indicated that the contiguous presentation of grapho-phonological information that isolated and separated the presentation of grapho-phonological variance was beneficial for reading and spelling outcomes with grade 2 students (Adams, 1990).

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Chapter Eleven GLOSSARY

Acquired dyslexia occurs when a literate person experiences physical trauma or damage to the brain resulting in reading impairment.

Ambigious words belong to rime families whose individuals involve even distribution between the major and minor letter-sound correspondences and pronunciations for example in the words containing the rimes *own* (TOWN/GROWN) and *ove* (LOVE/DROVE) (Seidenberg et al., 1984).

Atypical irregular words cannot be decoded using GPC rules, and the rime bodies of atypical irregular words (e.g. monk, steak, comb) are inconsistent relative to other members of the same rime family from. (For more information see the entry 'typical' in this Glossary.)

Consistency effect This occurs when prior knowledge of similar spelling patterns and neighbourhood friends in rime families affects the identification, recognition, learning and pronunciation of words (Glushko, 1979; Zorzi, Houghton, & Butterworth, 1998b). The consistency effect and the regularity effect are both sensitive to frequency. High frequency words have negligible consistency and regularity effects, and low frequency words demonstrate significant consistency and regularity effects (Seidenberg and McClelland, 1989). An analysis of word frequency lists has revealed that high frequency words contain a disproportionately greater preponderance of irregular spelling patterns than low frequency words. Low frequency words tend to be more regular and rule governed, and high frequency words tend to retain antiquated morphemic information that is often lost in low frequency words (Adams, 1990; Pinker, 1998; Treiman, Mullennix, et al., 1995). Even though high frequency words are often irregular they produce minimal regularity effects due to the frequency effect that attributes an automatic recognition status to high frequency words whereby they are read more quickly and accurately (Seidenberg et al., 1984).

Consistent regular words can be decoded using GPC rules and the rime families from which they are taken do not possess any inconsistent members (e.g., wisp, weld, spike). That is, all their neighbours are friends and they have no enemies.

Consistent typically irregular words have a pronunciation that is different from that expected by GPC rules, and within the rime family there are no exceptions that is no words that have a different pronunciation.

Consistent words share the same orthographic body and pronunciation as other words in their rime family. The computational models of Seidenberg and McClelland (1989) and Plaut, McClelland, Seidenberg and Patterson (1996) extend the definition of consistency to include onsets as well as rimes. That is, words with a consistent onset share the same orthographic representations and pronunciations as other words with that onset. Words with inconsistent onsets have a different pronunciation to other words sharing the same orthographic onset for example, CHEF. Inconsistent words are also known as enemies and have a pronunciation different from the other words in their orthographic rime family (e.g., PINT). Research previous to the landmark computational model of Seidenberg and McClelland (1989) confined consistency effects to the rime. Treiman et al. (1995) have extended consistency effects to each of the sublexical units the rime, the onset, the antibody and the vowel. 'Consistency' and 'contiguity' have in common the coincidental identity of orthographic and phonological information. Glushko suggested that words should be categorised as consistent if all the members in the rime family have the same rime pronunciation as in the rime family *list*.

Contiguous presentation/intervention or contiguity of grapho-phonological information refers to the consistent presentation of grapheme and phoneme correspondences that avoids both phonological and orthographic variance.

Deep and shallow orthographies are defined according to the amount of orthographic and phonological variance in the alphabetic script. Where these forms of variance are minimised and the grapheme-phoneme correspondences are highly predictable the language is said to be a shallow alphabetic orthography. On the other hand where the grapheme-phoneme correspondences are unpredictable and morphemically determined the language is deemed to be a deep alphabetic orthography. Shallow orthographies have a high degree of contiguity in grapheme-phoneme correspondences. (Foorman, 1994; Seymour, 1990: Seidenber and McClelland, 1989)

Enemies are members of a rime family that have an inconsistent pronunciation compared to the consistent pronunciation of its other members.

Exception words deviate from the major letter-sound correspondence rules of Venezky and have the appearance of being regular but have different pronunciations (e.g., *have* and *give* (Waters, Seidenberg, & Bruck, 1984). These are also known as inconsistent words and atypical regular words or atypical irregular words (see footnote #3 on the concept of typicality).

Frequency effect refers to the frequency with which a word occurs in print. The more frequently a word occurs in print the more quickly and accurately a word is recognised and named. Calculations regarding the frequency of a word are referred to as the token value of the word. The less frequently a word occurs in print the longer the response time and the more errors are made recognising and naming that word (Seidenberg et al., 1984; Seidenberg and McClelland, 1989).

Friends are members of rime families that have a pronunciation consistent with that of the other members of that family.

Functional MR imaging (fMR) detects signals from those areas of the brain that are activated by cognitive tasks. Cognitive activity generates a cerebral blood flow of oxygenated blood to depleted deoxygenated vascular tissue. This exchange produces a uniform paramagnetic field that is translated into fMR images that track the functional organisation of the brain.

Go/no go decision task is when words are named and nonwords are left unnamed.

Grapheme A grapheme is the written representation of a phoneme and may contain one or more letters (Rastle & Coltheart, 1998).

Grapheme to phoneme conversion (GPC) rules characterise a process whereby words are graphemically parsed, and the graphemes are assigned to phonemes and blended to produce a pronunciation.

Graphotactic constraints are rules preventing orthographically unacceptable sequences of letters from occurring in text (e.g., "ck" does not appear in the initial position of an English word, and "q" is invariably followed by "u". (Laxon, Coltheart, & Keating, 1988).

Inconsistent typically regular words can be decoded by GPC rules, but their rime family has at least one word that has a different pronunciation from the rest of that rime family (e.g. *leaf; deaf*). (For more information see the entry 'typical' in this glossary.)

Inconsistent words Words are categorised as inconsistent if one or more of the members of the rime family has an alternate pronunciation (Glushko, 1979).

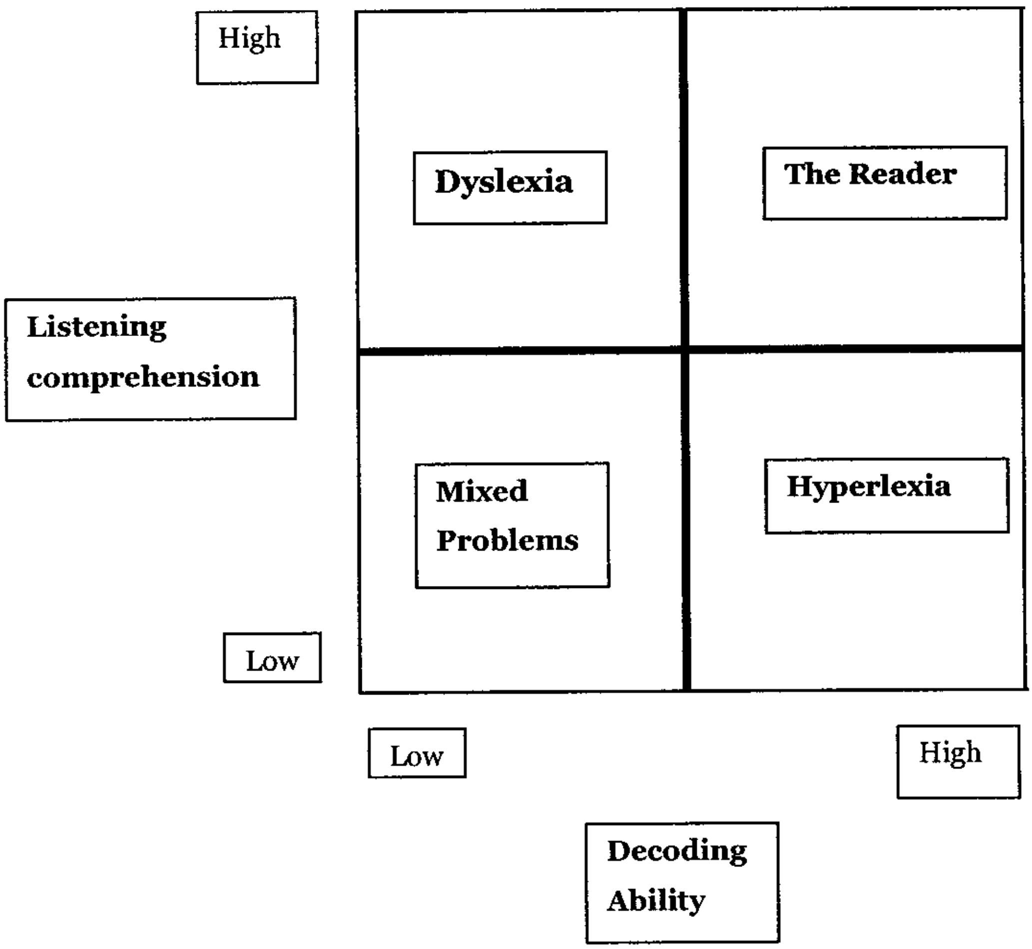
Level of distinctness Distinctness in speech perception studies refers to the number of distinct phonetic features in the articulation of a word (e.g., the word AND can be pronounced *and* when stressed and *an* when unstressed). The level of distinctness for scoring purposes in the research is calculated by the percentage of "maximally distinct vowels pronounced in accordance with the written form" (Elbro et al., 1998, p. 46).

Lexical route involves the identification of a word on the basis of its specific orthography and the consequent derivation of its phonological analogue from an internal lexicon located in the individual's long-term memory (Coltheart, 1978).

Morphology will sometimes refer to a combination of the grammatical components and form of words together with their meanings (Giraudo and Grainger, 2000) and sometimes will only refer to the grammatical components and form of words. The morphological and grammatical content of words will be separated from their semantic value where pertinent.

Neighbourhood *N* This effect relates to the cascaded activation of orthographically similar words that differ from a target word by only one letter (Coltheart et al., 2001).

Neighbours The term 'neighbours' refers to words that share the same orthographic rime and pronunciation as other words in a rime family.



Nicholson's model of reading abilities

The Above Diagram is a Matrix Demonstrating the Relationship between Listening Comprehension, Decoding Skill and Reading Ability (Nicholson, 1986).

Nonlexical route involves parsing the graphemic structure of a word into its corresponding phonological components and synthesising the grapheme-phoneme correspondences to derive the word's pronunciation (Coltheart, 1978).

Non-word/s or pseudoword/s are words that do not contain lexical information, and are therefore processed using the nonlexical route according to the Dual Route Model (Coltheart, 1978).

Onset An onset consists of the beginning consonant (s) of a word or syllable (if any) before the vowel and the rime comprises the vowel and final consonant (s) (if any).

Orthographic constraints For example, '*gh*' does not occur at the beginning of a word, see also graphotactic constraints.

Orthographic measures of processing include:- word pseudohomophone choice (e.g., *rain/rane; sammon/salmon*) where the correct spelling is chosen, nonlexical choice (e.g.,*filv,filk; moke,moje; powl, lowp*) where the most wordlike nonword is chosen, orthographic verification (*street or streat*) between auditory presentation and visual image, homophone choice (e.g., "Which is a fruit?" *pear/pair*), homophone verification (e.g., cloudy: *clowdy, cloady, cloudey, cloudy*), detection of letter clusters (e.g., auditory presentation of *clock*, choose onset *cl* or *c o*) and exception word spelling (e.g., *comb*) (Foorman, 1994.)

Orthographic variance occurs when the same phoneme can be represented by different graphemes, Rastle and Coltheart (1999b) call these representations 'heterographic homophones'.

Phoneme Phonemes consist of classes of phones that are referred to as allophones. That is, the 't' in ten, bite, stop, etc. are allophones of that English phoneme (Wagner & Torgesen, 1987) but themselves have slightly different pronunciations. Australian English has 18 vowels and 25 consonants making 43 phonemes in all (Rastle & Coltheart, 1999b). Phonemes are defined as units of speech that are closer to units of meaning than phones. Phones are closer to units of sound and can vary from one word to another. These variant phones in different words are called 'allophones'. Phonemes can contain more than one phone for example long vowel sounds and some consonantal polyphones like /x/ (Treiman, 1993).

Phonological recoding This term will be the preferred expression for the process of converting orthographical material to speech. The process of deriving speech-based material from printed letter strings is variously referred to as "decoding"/ "code emphasis"/ "phonological processing"/ "nonlexical route"/ "grapheme-phoneme conversion" and more. Each of these concepts embodies different sets of assumptions and they are not strictly interchangeable (Share, 1995)

Phonological variance occurs when the same grapheme represents different phonemes, Rastle and Coltheart (1999b) call these representations 'homographic heterophones'.

Phonotactic constraints relate to the specific phonology of a language and ensure that sequences of phonemes that are difficult to pronounce do not occur together. For example, “md”, “np” or “tp” do not occur together except when they are separated by syllable boundaries (Laxon, Coltheart, & Keating, 1988).

Pinyin is a phonemic Chinese orthographic system used for academic purposes as distinct from the normal nonphonemic Chinese characters.

Protoliteracy is the term given to a knowledge of both the names of the letters and the major sounds of the letters in the alphabet (Barron, 1994). The sounds that letters represent are distinct from the names of those letters and protoliteracy is established when children are conversant with this distinction. It does not extend beyond the confines of the written alphabet to frequently occurring letter patterns.

Regular Words are those words whose pronunciation can be predicted on the basis of major letter-sound correspondences or rules as analysed by Venezky (1970) (e.g., *made* or *best*).

Regularisation errors occur when irregular words are pronounced as if they were regular and are therefore mispronounced.

Regularity effect The regularity effect is present when low frequency regular words are read more quickly and accurately than low frequency irregular words (Seidenberg and McClelland, 1989). Reading exception words via the nonlexical route produces regularization errors. The effect is measured by naming latency and error rates. Words have been classified as regular, irregular or exception, strange, unique, ambiguous, consistent or inconsistent depending on the complexity of their grapheme-phoneme correspondences and their relation to other similar words. The different types of words form a continuum from transparent regular words with predictable and stable letter-sound correspondences to opaque, highly irregular words with unpredictable and unique letter-sound correspondences (Rack et al., 1992).

Rime The rime comprises the vowel and final consonant (s) (if any) (Subsyllablic units below).

Speech perception is the name given to the initial mechanism that encodes phonological information (Brady, 1997).

Strange words contain unusual spellings and irregular letter-sound correspondences for example *aisle* and *ache* (Waters et al., 1984).

Stroop Effect For example, when the word RAT has its initial letter in common with the word RED, POD has its final letter in common with the word RED and the words RAT and POD are presented in the colour red and the anticipated correct response is “red”. Also a faster response “red” is anticipated to the red word POD in this situation than to the red word KIT.

Subsyllabic Units

Tier 1

syllable
/twist/

Tier 2a

anti-Body	coda/tail
/twi/	/st/

Tier 2b

onset/head	rime/body
/tw/	/ist/

Tier 3

onset/head	peak/nucleus/torso	coda/tail
/tw/	/i/	/st/

Tier 4

phoneme	phoneme	phoneme	phoneme	phoneme
/t/	/w/	/i/	/s/	/t/

Diagram of Varieties of Subsyllabic Units (Based on Seymour, et al., 1999).

The diagram above shows a theoretical hierarchy of sublexical units ordered from largest (tier 1) to smallest (tier 4). In it, the syllable (tier 1) may be viewed phonologically as the smallest unit of speech that is intuitively countable. Phonetically it is characterised by a relative peak of sonority , which is most typically a vowel. It is commonly accepted that every syllable must contain a vowel (Spalding and Spalding, 1969; Ehri, 1997), but there are exceptions such as consonantal syllables (e.g. "ble" as in "able", "kle" as in "ankle" etc.) where the vowel is included orthographically but not pronounced. The finest grain sublexical units are the phonemes (tier 4). Intermediate tiers involve patterns of phoneme combinations. Tier 3 consists of the onset/head, peak/torso and coda/tail. The onset or head is made up of any consonants before the vowel. The peak or nucleus (torso) refers to the vowel (s). The coda or tail consists of the consonants following the nucleus. Above this is tier 2a consisting of the antibody (onset + nucleus) + coda, and tier 2b consisting of onset + rime (nucleus + coda). Whereas the antibody consists of the head plus the nucleus, the rime or body consists of the nucleus plus the coda (Rastle, & Coltheart, 1999b, Seymour, Duncan, & Bolik, 1999). A word body becomes a rime body when it is paired with other word bodies that share the same vowel + coda, (e.g., teen, seen, been).

Subtraction methodology A subtraction methodology was used to trace the following (see table below) cognitive tasks to corresponding localised areas of the brain. Different modules of the brain were detected by the fMR imaging technique to have been activated by the specific cognitive processes (Fulbright et al., 1997).

Task	Stimuli	Processes Engaged
Line	//\\\\//	visual-spatial
Case	BtBT	visual- spatial+orthographic
Rhyme	LETE	visual-spatial + orthographic +
	JEAT	phonologic
Category	CORN	visual-spatial + orthographic +
	RICE	phonologic + semantic
Subtractions		Processes isolated
Case - Line		orthographic
Rhyme - Line		orthographic+phonologic
Rhyme - Case		phonologic
Category - Line		orthographic+phonologic+
		semantic
Category Rhyme		semantic
Category - Case		phonologic+ semantic

Third factor Bryant and Bradley (1985) mention the principle of tertium quid or the third factor. "A" may cause "B" while a third factor "C" may cause both "A" and "B". For instance, a speech impediment ("A") may cause a reading and writing difficulty ("B") since a person may write the way he speaks, when the real cause of both difficulties is a lack of phonological awareness ("C").

Token measure A *token* measure is calculated by summing the frequency of the words used in calculating a type measure. A token measure is calculated by the ratio of the summed frequency of friends relative to the total summed frequency of friends and enemies. The result is useful since common words have a greater impact than rare ones (e.g., /ea/ has a low token frequency because both long /e/ and short /e/ pronunciations are frequent (Treiman, Mullennix et al., 1995).

Transcoding is the process of mapping graphemes-phonemes and phonemes-graphemes, and represents a metalinguistic application of the alphabetic principle. (Monsell, Patterson, Graham, Hughes & Milroy,1992).

Type measure A *type* measure is the number of neighbours in the corpus of words that share the same constituent letters in the same sublexical unit. It is calculated by the ratio of the number of friends relative to the total number of friends + enemies (Treiman, Mullennix et al., 1995).

Typical means having the pronunciation that is most often associated with a particular orthographic rime as defined by both type and token frequency within monosyllabic English words (Bowey, 1996, p.118). Typical and GPC pronunciations of rimes usually converge (e.g. /ist/ short 'I'). The short 'e' sound in 'sweat' is typically irregular orthographic rime because most words with the rime body /ea/ are pronounced with the long /e/ sound as in EAT and form a family of typically regular orthographic rimes. Typical irregular words are ones where the rime is more frequently given the irregular pronunciation (e.g. *find*) and atypically irregular words are less frequently given an irregular pronunciation. For example, BOWL has a long /o/ sound while most words in this rime family are given the 'ow' sound as in FOWL (Shallice and McCarthy 1985).

Typically irregular words constitute a rime family of words that can not be decoded using GPC rules (e.g. grind, palm, chalk). (For more information see the entry 'typical' in this glossary.)

Unique words, like soap have no 'friends' and no 'enemies' (Jared, McRae & Seidenberg, 1990).

Word families The contiguous intervention presents exemplars of word families as distinct from rime families in that the final consonant varies and the consistently targeted grapheme-phoneme correspondence only involves the vocalic nuclei or other letter-sound correspondences. Word families also refer to derivationally related words (e.g., curious, curiosity) but in the interventions in this research word families relate to groups of words that share the same letter-sound correspondences as a defining characteristic of each set of words to be sorted (Stanback, 1991).

Word length effect The word length effect occurs when longer low frequency words are read more slowly and less accurately than similar words containing fewer letter.

APPENDIX A

Sample Lessons from Study 1:-

Contigious Lessons 1 and 3 (Lessons 1-2 & 3-4 followed the same format)

Phoneme Lesson 5 (Lessons 15-12 followed the same format)

Grapheme Lesson 13 (Lessons 13-20 followed the same format)

Sample Lessons from Study 2:-

Contiguous Lesson 1 (Lessons 1-4 followed the same format)

Phoneme Lesson 5 (Lessons 5-11 followed the same format)

Grapheme Lesson 12 (Lessons 12-20 followed the same format)

Intervention Word List

The Appendix also contains a complete List of all words from both studies excluding the words from the sample lessons of study 2 (Contiguous lesson 1, Phoneme lesson 5, and Grapheme lesson 12).

If you need help, ask by putting up your hand.

Lesson 1 Contiguous Presentation Study 1

1. I would like you and your partner to sort the following words into piles.
2. Take a card and say the word slowly.
3. As you stretch out the word, listen carefully to the sounds in the word.
4. Listen carefully to the sounds underlined.
5. Put down one card that you have worked on.
6. Take another card. Does the underlined letter(s) have the same sound as the first card?
7. When the underlined sound is the same, put the card on top of the other card. When the underlined sound is different, make a new pile.

Here are today's words:-

	letters	sounds		letters	snds		letrs	snds
hat sit bus			hot strong hundred distress			cramp picnic nest		

Ask when you do not know a word.
How many piles do you have............................?
Things to think about:-
1. How many letters in ....?
2. How many sounds in ....?
3. What did you learn about these sounds?
....
....
....
....
4. What is a new example of...............................
5. What does .... mean?
....
....
Please ask questions.

Listening to Sounds. Name..

If you need help, ask by putting up your hand.

Lesson 3 Contiguous Presentation Study 1

1. I would like you and your partner to sort the following words into piles.
2. Take a card and say the word slowly.
3. As you stretch out the word, listen carefully to the sounds in the word.
4. Listen carefully to the sounds underlined.
5. Put down one card that you have worked on.
6. Take another card. Does the underlined letter(s) have the same sound as the first card?
7. When the underlined sound is the same, put the card on top of the other card. When the underlined sound is different, make a new pile.

Here are today's words:-

New Word	Pile 1	Pile 2	Pile 3	Misc.
sock smack clock car scarf garden fork horse story				

How many piles do you have.............................?

New Word	Number of letters in word	Number of sounds in word	Tricky spot 1	Tricky spot 2
sock smack clock car scarf garden fork horse story				

Listening to Sounds. Name..

If you need help, ask by putting up your hand.

Can you make other words with these bits? (You may use the letters from below the box).

New Word	My word 1	My word 2	My word 3	My word 4
sock	ock	ock	ock	ock
smack	ack	ack	ack	ack
clock	eck	eck	eck	eck
car	ar	ar	ar	ar
scarf	art	art	art	art
garden	arb	arb	arp	arp
fork	ork	ork	ork	ork
horse	ort	or	ort	ort
story	ory	ory	orm	orn

b,c,d,f,g,h,j,k,l,m,n,p,qu,r,s,t,v,w,x,y,z starts with sp, st, sc, ,sm, sn, sl, sw, tw, dw, bl, cl, gl, fl, pl, pr, br, tr, dr, cr, gr, fr.Ends with:-st, ft, lk, ld, pt, sp, ct, lp, lt, xt, nd, nt, nch, mp, nk.

Also consider thr, spr, squ, spl, shr, str, scr

Revision.

Are the underlined sounds in the list of words different or the same?

Reorder these words so that the words with the same sound are next to each other.

Lesson 1	clusters	Lesson 2	clusters	Lesson 3	
hat		queen			
sit		food			
bus		screen			
hot		freedom			
strong		roof			
hundred		zoom			
distress					
cramp					
picnic					
nest					

Listening to Sounds. Name..

If you need help, ask by putting up your hand.

Lesson 5 Phoneme Presentation Study 1

1. I would like you and your partner to sort the following words into piles.
2. Take a card and say the word slowly.
3. As you stretch out the word, listen carefully to the sounds in the word.
4. Listen carefully to the sounds underlined.
5. Put down one card that you have worked on.
6. Take another card. Does the underlined letter(s) have the same sound as the first card?
7. When the underlined sound is the same, put the card on top of the other card. When the underlined sound is different, make a new pile.

Here are today's words:-

New Word	Pile 1	Pile 2	Pile 3	Misc.
apron				
gate				
play				
train				
straight				
gaol				
gauge				
grey				
veins				
reign				
mother				

How many piles do you have............................?

New Word	Number of letters in word	Number of sounds in word	Tricky spot 1	Tricky spot 2
apron				
gate				
play				
train				
straight				
gaol				
gauge				
grey				
veins				
reign				
mother				

Listening to Sounds. Name...

If you need help, ask by putting up your hand.

Can you make other words with these bits? (You may use the letters from below the box).

New Word	My word 1	My word 2	My word 3	My word 4
apron	pril	von	ble	ble
gate	ate	ane	ape	ade
play	ay	ay	ay	ay
train	ain	ain	ain	ain
straight	aight	eight	eak	eak
gaol	ale	ail	ale	ail
gauge	age	ame	ame	age
grey	ey	ey	ey	ey
veins	ein	ase	ase	ase
reign	avy	avy	ave	ave

b,c,d,f,g,h,j,k,l,m,n,p,qu,r,s,t,v,w,x,y,z, kn,pn,gn,ch,sh,th,ph,rh,wh.
Starts with sp, st, sc, ,sm, sn, sl, sw, tw, dw, bl, cl, gl, fl, pl, pr, br, tr, dr, cr, gr, fr. Ends with:-st, ft, lk, ld, pt, sp, ct, lp, lt, xt, nd, nt, nch, mp, nk.
Also consider thr, spr, squ, spl, shr, str, scr

Revision.
Are the underlined sounds in all the words different or the same?
Circle the sounds that are different to the /u/ in 'umbrella' for lesson 4.
Circle the sounds that are different to the /i/ in "igloo" for lesson 2.
Circle the sounds that are different to the /o/ in 'dog' for lesson 3.

Lesson 4	Lesson 2	Lesson 3
umbrella	igloo	dog
mother	build	watch
country	busy	Australia
does	pyjamas	cough
flood	pretty	John
cupboard	forfeit	honest
around	sieve	luncheon
	women	knowledge

Listening to Sounds. Name..

If you need help, ask by putting up your hand.

Lesson 13 Grapheme Presentation Study 1

Sort the cards by listening to the sounds of the underlined letters. If the sounds are the same put them together. If the sounds are different, make a new pile or put them in the miscellaneous column.
Do the letters show you the sounds? When you hear the sound, will you know the letter?
Here are today's words:-

New Word	Pile 1	Pile 2	Pile 3	Pile 4	Pile 5	Misc.
how snow brown crow chief tie brief die sieve obey achieve sigh						

How many piles do you have............................

New Word	Number of letters in word	Number of syllable sounds	Sounds in first Syllable	Sounds in next Syllable	Total number of sounds	Tricky spot 1	Tricky spot 2
how							
snow							
brown							
crow							
chief							
tie							
brief							
die							
sieve							
achieve							

Listening to Sounds. Name...

If you need help, ask by putting up your hand.

Can you make other words with these bits? (You may use the letters from below the box).

New Word	My word 1	My word 2	My word 3	My word 4
how	ow	ow	owl	owl
snow	own	own	own	own
brown	owse	owth	iece	iece
crow	ie	ie	ie	ie
chief	ied	ied	ied	ied
tie	rried	rried	ptied	iege
brief	ief	ield	ield	ield
die	iend	ierce	ierce	ier
sieve	ies	ies	ies	ies
achieve	ities	tories	erries	opies

b,c,d,f,g,h,j,k,l,m,n,p,qu,r,s,t,v,w,x,y,z, kn,pn,gn,ch,sh,th,ph,rh,wh.
Starts with sp, st, sc, ,sm, sn, sl, sw, tw, dw, bl, cl, gl, fl, pl, pr, br, tr, dr, cr, gr, fr. Ends with:-st, ft, lk, ld, pt, sp, ct, lp, lt, xt, nd, nt, nch, mp, nk.
Also consider thr, spr, squ, spl, shr, str, scr

Revision.
Are the underlined sounds in all the words different or the same?
Group the words where the /s & x/ sound is the same (lesson 10).
Group the words where the /ou/ sound is the same (lesson 11).
Group the words where the /igh & ey/ sound is the same (lesson 12).

Lesson 10	Lesson 11	Lesson 12
as	shout	sigh
sets	count	blight
rose	mould	sprightly
sister	shoulder	grey
raise	boulder	obey
serious	soup	survey
realise	route	convey
six	routine	monkey
excuse	country	jockey
boxer	couple	honey

Listening to Sounds. Name..

If you need help, ask by putting up your hand.

Lesson 1. Contiguous Presentation Study 2

Please work with your partner in this lesson.
You have a set of cards with words on them.
Please sort the words into different piles.
Do it this way:-

1, Take a card and say the word slowly. (Stretch it out).
2. Listen carefully to the sounds in the word.
3. One sound on each card is underlined.
4. Listen carefully to the sounds underlined.
5. Put down the card that you have worked on.
6. Take another card. Look at the underlined letter(s).
7. Do they have the same sound as the first card?
8. If the underlined sound is the same, put the card on top of the other card. If the underlined sound is different, make a new pile.
9. Now write out the words on the cards in your first pile in column (1) in the box below. Check that all the underlined sounds are the same.

Write out the words in your 2nd pile in column 2. (Continue with your other piles in columns 3 and 4).

New Words	Pile 1	Pile 2	Pile 3	Pile 4
hat				
sit				
bus				
hot				
strong				
hundred				
distress				
cramp				
picnic				
nest				
hut				
rest				

b,c,d,f,g,h,j,k,l,m,n,p,qu,r,s,t,v,w,x,y,z, kn,pn,gn,ch,sh,th,ph,rh,wh. Starts with sp, st, sc, ,sm, sn, sl, sw, tw, dw, bl, cl, gl, fl, pl, pr, br, tr, dr, cr, gr, fr., spr, squ, spl, shr, str, scr. Ends with:-st, ft, lk, ld, pt, sp, ct, lp, lt, xt, nd, nt, nch, mp, nk.

Listening to Sounds. Name..

If you need help, ask by putting up your hand.

Counting syllables in words.

1. Look at the words in the first column.
2. Say the first word slowly.
3. Clap each part of the word as you say it slowly.
4. How many times did you clap............?
5. How many syllables do you hear.......?
6. In the box below, start with the fourth word and write the syllables of each word into the columns.

	First syllable	Second syllable	third syllable
hat	hat		
sitting	sit	ting	
buttering	but	ter	ing
hot			
strong			
hundred			
distress			
cramp			
picnic			
nest			
hut			
restful			

b,c,d,f,g,h,j,k,l,m,n,p,qu,r,s,t,v,w,x,y,z, kn,pn,gn,ch,sh,th,ph,rh,wh. Starts with sp, st, sc, ,sm, sn, sl, sw, tw, dw, bl, cl, gl, fl, pl, pr, br, tr, dr, cr, gr, fr., spr, squ, spl, shr, str, scr. Ends with:-st, ft, lk, ld, pt, sp, ct, lp, lt, xt, nd, nt, nch, mp, nk.

Listening to Sounds. Name...

If you need help, ask by putting up your hand.

Lesson 5. Phoneme Presentation Study 2.

Sort the cards by listening to the sounds of the underlined letters. If the sounds are the same put them together. If the sounds are different, make a new pile or put them in the miscellaneous column.
Do the letters show you the sounds? When you hear the sound, will you know the letter?

New Words	Pile 1	Pile ?
apron		
gate		
play		
train		
straight		
gaol		
gauge		
grey		
veins		
reign		
mother		

How many piles do you have ....?
Counting syllables in words.
1. Say the first word slowly. 2. Clap each part of the word as you say it slowly.
3. How many times did you clap.......? 4. How many syllables do you hear.......?

	First syllable	Second syllable	Third syllable
gate	gate		
apron	a	pron	
play			
train			
straight			
gaol			
gauge			
grey			
veins			
reign			
mother			

b,c,d,f,g,h,j,k,l,m,n,p,qu,r,s,t,v,w,x,y,z, kn,pn,gn,ch,sh,th,ph,rh,wh. Starts with sp, st, sc, ,sm, sn, sl, sw, tw, dw, bl, cl, gl, fl, pl, pr, br, tr, dr, cr, gr, fr., spr, squ, spl, shr, str, scr. Ends with:-st, ft, lk, ld, pt, sp, ct, lp, lt, xt, nd, nt, nch, mp, nk.

Listening to Sounds. Name...

If you need help, ask by putting up your hand.

1. We will now learn the onset and rime of a syllable.
2. From the above exercise how many syllables does the third word have?
3. Say the first syllable of this word slowly.
4. Do you hear the beginning sound(s)? This is the onset.
5. Do you hear the end sound(s)? This is the rime.
6. In the box below write the beginning sound(s) of each syllable in the onset box. Write the end sound(s) of each syllable in the rime box.

Word	First Syllable		Second Syllable	
gate	gate			
(Onset/rime)	g	ate		
apron	a		pron	
(Onset/rime)	a		pr	on
play				
(Onset/rime)				
train				
(Onset/rime)				
grey				
(Onset/rime)				
vein				
(Onset/rime)				
reigning				
(Onset/rime)				
motherly				
(Onset/rime)				

Can you make other words with these bits? (You may use the letters from below the box).

New Word	My word 1	My word 2	My word 3	My word 4
apron	pril	von	ble	ble
gate	ate	ane	ape	ade
play	ay	ay	ay	ay
train	ain	ain	ain	ain
straight	aight	eight	eak	eak
gaol	ale	ail	ale	ail
gauge	age	ame	ame	age
grey	ey	ey	ey	ey
veins	ein	ase	ase	ase
reign	avy	avy	ave	ave

b,c,d,f,g,h,j,k,l,m,n,p,qu,r,s,t,v,w,x,y,z, kn,pn,gn,ch,sh,th,ph,rh,wh. Starts with sp, st, sc, ,sm, sn, sl, sw, tw, dw, bl, cl, gl, fl, pl, pr, br, tr, dr, cr, gr, fr., spr, squ, spl, shr, str, scr. Ends with:-st, ft, lk, ld, pt, sp, ct, lp, lt, xt, nd, nt, nch, mp, nk.

Listening to Sounds. Name...

If you need help, ask by putting up your hand.

Lesson 12. Grapheme Presentation Study 2

Sort the cards by listening to the sounds of the underlined letters. If the sounds are the same put them together. If the sounds are different, make a new pile or put them in the miscellaneous(miscel.) column.

New Words	Pile 1	Pile 2	Pile 3	Miscel.
sigh				
blight				
sprightly				
grey				
obey				
survey				
convey				
monkey				
jockey				
honey				
alley				
shout				

How many piles do you have ....?
Listen to the onset and rime of each syllable.

Word	First Syllable		Second Syllable	
sigh	sigh			
(Onset/rime)	s	igh		
survey	sur		vey	
(Onset/rime)	s	ur	v	ey
convey				
(Onset/rime)				
monkey				
(Onset/rime)				
alley				
(Onset/rime)				
grey				
(Onset/rime)				
obey				
(Onset/rime)				

b,c,d,f,g,h,j,k,l,m,n,p,qu,r,s,t,v,w,x,y,z, kn,pn,gn,ch,sh,th,ph,rh,wh. Starts with sp, st, sc, ,sm, sn, sl, sw, tw, dw, bl, cl, gl, fl, pl, pr, br, tr, dr, cr, gr, fr., spr, squ, spl, shr, str, scr. Ends with:-st, ft, lk, ld, pt, sp, ct, lp, lt, xt, nd, nt, nch, mp, nk.

Listening to Sounds. Name...

If you need help, ask by putting up your hand.

Now we will listen to all the sounds in a word.

(1) Divide the word into syllables. (2) Say the syllable slowly.

(3) Record each sound of each syllable in the boxes provided.

Words	Is there a tricky spot between the letters and sounds?				Totals	
Count the number of letters and put the total in the box with (_)						
sigh	syllables	sigh			1	
	sounds	s igh			2	4
obey	syllables	o	bey		2	
	sounds	o	b ey		3	4
blight	syllables					
	sounds					_
grey	syllables					
	sounds					_
convey	syllables					
	sounds					_
jockey	syllables					
	sounds					_
honey	syllables					
	sounds					_
alley	syllables					
	sounds					_

Can you make other words with these bits? (You may use the letters from below the box).

New Word	My word 1	My word 2	My word 3	My word 4
sigh	igh	igh	igh	igh
blight	ight	ight	ight	ight
sprightly	ightly	ightly	ightily	ighteous
grey	_hey	_eighbour	eight__n	eight_
obey	_eight	f_eight	_eign	_eign
survey	v__n	r__n	vei_	
convey	ey	ey	ey	ly
monkey	_oney	_lley	_onkey	_urkey
jockey	_oey	_himney	_arley	_bbey
honey	_alley	_idney	_rolley	_sprey

b,c,d,f,g,h,j,k,l,m,n,p,qu,r,s,t,v,w,x,y,z, kn,pn,gn,ch,sh,th,ph,rh,wh. Starts with sp, st, sc, ,sm, sn, sl, sw, tw, dw, bl, cl, gl, fl, pl, pr, br, tr, dr, cr, gr, fr., spr, squ, spl, shr, str, scr. Ends with:-st, ft, lk, ld, pt, sp, ct, lp, lt, xt, nd, nt, nch, mp, n

b,c,d,f,g,h,j,k,l,m,n,p,qu,r,s,t,v,w,x,y,z, kn,pn,gn,ch,sh,th,ph,rh,wh. Starts with sp, st, sc, ,sm, sn, sl, sw, tw, dw, bl, cl, gl, fl, pl, pr, br, tr, dr, cr, gr, fr., spr, squ, spl, shr, str, scr. Ends with:-st, ft, lk, ld, pt, sp, ct, lp, lt, xt, nd, nt, nch, mp, nk.

Intervention Word Lists

Contiguous 2	Contiguous 3	Contiguous 4	Contiguous 5	Contiguous 6	Contiguous 7
queen	sock	case	sheep	paint	thirsty
food	smack	change	wish	appear	mountain
cramp	clock	five	punish	groan	flour
toad-stool	car	ice	chimney	cream	first
freedom	scarf	rope	thin	mountain	biscuit
roof	garden	explode	bench	soap	proud
hundred	fork	blue	threw	really	mouse
distress	horse	tune	cherry	afraid	circuit
screen	story	cure	thicken	roar	south
zoom			orchard	explain	twirl
strong			hothead	roast	afraid
			shepherd		shirt
Contiguous 8	**Contiguous 9**	**Contiguous 10**	**Contiguous 11**	**Contiguous 12**	**Contiguous 13**
play	burst	point	Daddy	bright	cry
knee	lawn	turnip	head	after	snow
decay	decay	swerve	crowd	son	wrap
scene	curl	choir	grumpy	bath	why
knife	lawyer	small	brown	sight	wrong
payable	purse	different	read	feather	grow
circuit	house	poison	choir	mother	answer
knot	thaw	walk	threat	fast	spying
scent	purpose	always	however	sigh	some
pliable	squaw	lawn	finally	love	sword
knew	turnip	nervous	meant	frighten	marrow
scissors	road	central	poison	smoking	front
Contiguous 14	**Contiguous 15**	**Contiguous 16**	**Contiguous 17**	**Contiguous 18**	**Contiguous 19**
new	sauce	hair	phone	brought	build
nation	behind	touch	both	war	scene
hymn	hear	was	care	gnat	balance
grew	tidy	young	sold	ought	entrance
autumn	cause	wasp	graph	gname	guess
station	near	pair	spare	reward	science
condemn	beard	country	elephant	sign	guilty
screw	lion	stairs	only	quarter	scissors
snow	automatic	couple	parents	enough	distance
relation	find	double	hare	cough	alliance
wrap	nation	lion	want	gold	tough
column	chew	squash	trouble	dare	warm

Contiguous 20	Phoneme 1	Phoneme 2	Phoneme 3	Phoneme 4	Phoneme 6
castle	hen	igloo	dog	umbrella	me
able	said	build	watch	mother	trapeze
honour	bury	busy	Australia	country	tree
reliable	heifer	sieve	cough	does	eat
listen	bread	pyjamas	John	flood	people
favour	aeroplane	pretty	honest	cupboard	weight
stable	leopard	forfeit	luncheon	around	quay
often	privilege	privilege	knowledge	under	taxi
colour	friend	friend		up	baby
whistle	many	women			key
ignorance	says	says			phoenix
guide		many			
Phoneme 7	**Phoneme 8**	**Phoneme 9**	**Phoneme 10**	**Phoneme 11**	**Phoneme 12**
violin	open	music	owl	car	boy
pie	toe	due	house	galah	coin
ride	hose	tune	hour	aunt	buoy
ceiling	boat	nuisance	plough	father	ship
buy	snow	view	jug	are	boy's
light	owe	news	cage	clerk	pension
height	brooch	bury	girl	zoo	pressure
eye	oh!	youth	gypsy	scissors	sugar
dye	sew	yew	suggest	rose	action
island	Australia	beauty	bridge	boy's	social
aisle	boulder	ewe	giant	anxiety	machine
fly	dough	Europe	adjust	logs	fashion
Phoneme 13	**Phoneme 14**	**Phoneme 15**	**Phoneme 16**	**Phoneme 17**	**Phoneme 18**
rabbit	book	hoop	her	chair	kitten
van	snake	fish	ox (ks)	spare	queen
parrot	cent	to	learn	nest	cello
hat	could	offer	were	bear	chop
twelve	dress	phone	bird	inn	cat
ant	sword	two	exist (gs)	knife	duck
write	cycle	soup	surf	where	quay
of	pull	rough	figure	their	ditch
rhyme	city	blue	world	gnaw	notch
nephew	wolf	through	purr	prayer	school
cramp	psychic	half	journey	axe	Christmas
scraps	listen	could	anxiety (z = ds)	chicken	question

Phoneme 19	Phoneme 20	Grapheme 1	Grapheme 2	Grapheme 3	Grapheme 4
horse	deer	hat	hen,	sit	hot
sore	web	apron	smell	kite	pond
broad	top	path	legal,	ring	strong
soar	clear	was	chaos	find	over
pour	quick	cramp	nest	pilot	post
door	button	chaos	me	picnic	comb
war	pier	lazy	retry	final	to
chalk	debt	past	Neapol-itan	rigid	lose
paw	weir	sprang	distress	rise	move
fault	choir	father	father	risen	
sure	cigarette	wattle	sprang	incident	
thought	doubt	wash	wash		

Grapheme 5	Grapheme 6	Grapheme 7	Grapheme 8	Grapheme 9	Grapheme 10
bus	yet	cake	magic	quack	us
fluttered	yard	ceiling	gym	equal	as
unless	yahoo	scarf	germ	squad	sets
just	myth	certain	raging	queen	rose
music	pony	couple	goggle	this	sister
uniform	system	yahoo	gypsy	though	raise
guest	deny	city	gang	bathe	serious
pull	pygmy	cycle	huge	other	realise
pudding	empty	come	giant	thrill	six
hurry	style	circus	girl	thin	excuse
bullet	pylon	cup	pigeon	path	boxer
push		fancy	accent	throng	relax

Grapheme 11	Grapheme 12	Grapheme 13	Grapheme 14	Grapheme 15	Grapheme 16
cloud	sigh	how	dough	new	chop
shout	blight	snow	through	grew	school
count	sprightly	brown	though	blew	chef
mould	grey	crow	rough	screw	ache
shoulder	obey	chief	trough	phone	chute
boulder	survey	tie	tough	nephew	check
soup	convey	brief	cough	steward	echo
route	monkey	die	thought	few	Chinese
routine	jockey	sieve	plough	sinew	machine
country	honey	obey	sought	threw	spinach
couple	alley	achieve	drought	photograph	new
trouble	shout	sigh	bought	tough	phone

Grapheme 17	Grapheme 18	Grapheme 19	Grapheme 20		
hoop	eat	fruit	graded		
book	head	nuisance	loved		
door	break	for	wrecked		
snooze	heavy	pursuit	tinted		
shook	appear	juice	chopped		
poor	steak	port	fined		
shampoo	feather	cruise	wired		
boorish	great	conduit	missed		
goodness	really	doctor	flooded		
woo	meant	bruise	stopped		
choir	poor	really	doctor		
chute	snooze	meant	bruise		

APPENDIX B DUAL ROUTE CASCADED MODEL'S NONLEXICAL RULES

(Rastle, & Coltheart, 1999b pp. 490-496).

45 Australian Phonemes {238 rules in total}

Symbol	Example		Symbol	Example
1	bay		f	fat
2	buy		g	game
3	burn		h	had
4	boy		i	bean
5	no		j	yank
6	brow		k	cad
7	peer		l	lad
8	pair		m	mad
9	poor		n	nat
D	then		p	pat
E	pet		r	rat
I	pit		s	sap
J	cheap		t	tack
N	bang		u	boon
Q	pot		v	vat
S	sheep		w	why
T	thin		x	ugh
U	put		z	zap
V	putt		#	barn
Z	measure		{	pat
b	bad		_	jeep
d	dad			

Multiletter Rules (128 rules)

Grapheme	Phoneme	Position
		a=all b=beginning m=middle e=end

arre	#	A		cc	k	m,e
augh	9	A		ch	J	A
eare	7	A		ce	s	m,e
eere	7	A		ck	k	m,e
eigh	1	A		dd	d	m,e
ough	9	A		de	d	m,e
tsch	J	e		ea	i	A
urre	3	A		ee	i	A
ai.e	1	A		ei	1	A
ar.e	#	A		er	3	A
aw.e	9	A		eu	u	A
ea.e	i	A		ew	ju	A
ee.e	i	A		ey	1	A
er.e	3	A		ff	f	m,e
ie.e	i	A		ge	_	m,e

o.ue	5	A		gg	g	m,e
oa.e	5	A		gh	g	b
oi.e	4	A		gn	n	A
oo.e	u	A		ie	2	A
or.e	9	A		ir	3	A
ou.e	6	A		je	_	m,e
ow.e	6	A		jj	_	m,e
oy.e	4	A		kh	k	A
ur.e	3	A		kk	k	m,e
air	8	A		kn	n	b
are	8	A		le	l	m,e
arr	#	A		ll	l	m,e
awe	9	A		mb	m	m,e
aye	2	A		mm	m	m,e
ear	7	A		mn	m	m,e
eer	7	A		ng	N	m,e
ere	7	A		nn	n	m,e
err	3	A		oa	5	A
ewe	ju	A		oe	5	A
ier	7	A		oh	5	A
igh	2	A		oi	4	A
irr	3	A		oo	u	A
oar	9	A		or	9	A
oor	9	A		ou	6	A
ore	9	A		ow	6	A
our	9	A		oy	4	A
ure	9	A		ph	f	A
urr	3	A		pp	p	m,e
che	S	e		ps	s	b
dge	_	m,e		re	r	m,e
gue	g	m,e		rh	r	b
lle	l	m,e		se	s	m,e
que	k	m,e		sh	S	A
tch	J	m,e		ss	s	m,e
the	D	m,e		te	t	m,e
a.e	1	A		th	T	A
e.e	i	A		tt	t	A
i.e	2	A		ue	ju	A
o.e	5	A		ui	u	A
u.e	ju	A		ur	3	A
y.e	2	m,e		uy	2	m,e
aa	#	A		ve	v	m,e
ah	#	A		vv	v	m,e
ai	1	A		wh	w	b
ar	#	A		wr	r	b
au	9	A		x	ks	A
aw	9	A		ye	2	m,e
ay	1	A		ze	z	m,e
bb	b	m,e		zz	z	m,e

Context-Sensitive Rules: The grapheme outside the square brackets in Column 1 is converted to the phoneme in Column 2 in the presence of the preceding or following context specified in the square brackets. [V]=any vowel; [C]=any consonant. {10 rules}

gu[V]	g	b	c[i]	s	A
n[k]	N	A	c[y]	s	A
[q]u	w	m	[V][C]ed	d	e
g[e]	_	b	[V][C][C]	d	e
c[e]	s	A	[V][C][C][C]ed	d	e

Single-Letter Rules [64 rules]

a	{	b,m		n	n	A
a	#	e		o	Q	b,m
b	b	A		o	5	e
c	k	A		p	p	A
d	d	A		q	k	A
e	E	b,m		r	r	A
e	i	e		s	s	A
f	f	A		t	t	A
g	g	A		u	V	b,m
h	h	A		u	u	e
i	I	b,m		v	v	A
i	2	e		w	w	A
j	_	A		y	j	b
l	l	A		y	I	m
k	k	A		y	2	e
m	m	A		z	z	A

Output (phonotactic) Rules: The phoneme string in the first column is converted to the phoneme string in the second column. [36 rules]

#s	#z	e		ns	nz	e
1s	1z	e		us	uz	e
2s	2z	e		vs	vz	e
3s	3z	e		dT	tT	m,e
4s	4z	e		nk	Nk	m,e
5s	5z	e		pd	pt	m,e
6s	6z	e		kd	kt	m,e
7s	7z	e		Sd	St	e
8s	8z	e		Jd	Jt	e
9s	9z	e		rju	ru	A
Ds	Dz	e		Sju	Su	A
Ns	Nz	e		_ju	_u	A
bs	bz	e		lju	lu	A
ds	dz	e		Jju	Ju	A
gs	gz	e		sd	st	A
is	iz	e		tz	ts	A
ls	lz	e		Td	Tt	A
ms	mz	e		fd	ft	A

APPENDIX C

Reading Pre- and Posttest Study 1 and Study 2

(30 Regular Words, 30 Exception Words and 30 Nonwords randomly distributed).

Reading Pretest Study 1 & 2 (30 Regular Words, 30 Exception Words and 30 Nonwords Randomised and Mixed) Taken from Coltheart, M and Leahy (1996)					
hand	work	stench	brandy	pretty	pump
marsh	peril	chicken	bleaner	head	navy
baft	farl	iron	flannel	pofe	eye
yacht	life	tapple	nerve	wolf	drick
mist	drop	doash	pite	bick	give
check	shoe	tail	peef	blood	gop
rint	cord	delk	ceiling	routine	choir
take	bowl	bed	curb	trope	cough
context	meringue	framp	tomb	gauge	seldent
boril	bouquet	market	peng	brooch	brennet
break	chance	plant	wedding	long	friend
luck	ganten	free	middle	brinth	lose
crat	borp	gurve	stendle	soul	colonel
spatch	hest	norf	pint	weasel	come
sure	island	good	aspy	need	grenty

Reading Post-test Study 1 & 2. (30 Regular Words, 30 Exception Words and 30 Nonwords, Randomised and Mixed) Matched for frequency, and word length with Coltheart, M and Leahy (1996)					
pour	cane	vick	build	dop	crop
rapple	skim	dial	buoy	aisle	dite
touch	spot	saft	sixteen	onion	suit
torrent	feet	plane	strat	said	make
teng	exile	damp	asly	bamp	meef
smick	grocer	they	choose	chamois	done
fashion	rooster	palm	burve	beldent	weight
broplet	account	engine	job	torf	dough
beside	ballet	quarrel	gesture	crown	dredge
view	page	land	blatch	crope	toast
spendle	once	premiere	hust	fleaner	pearl
finger	lorp	gint	word	pelk	put
possum	toril	hull	sparl	quite	printh
grenpy	vein	mofe	fell	wait	pure
trough	soup	doath	does	santen	part

Spelling Pre- and Posttests:- Study 1 and Pretest Study 2

look	come	stolt
letter	covered	cred
dark	past	trid
reached	though	dast
since	heard	drent
himself	because	lappy
small	might	pred
set	own	ront
under	answer	filt
leaves	walked	gand
run	put	nulber
ground	should	naking
river	heavy	fud
ways	sure	grook
fine	gone	dret
back	does	brot
open	able	kell
making	living	gannel
getting	weather	pether
farm	done	mave

Spelling Pretest:- 20 Regular Words, 20 Exception Words and 20 Nonwords. (Carroll et al. (1971) 100-550 Highest Frequency Words, Random selection)

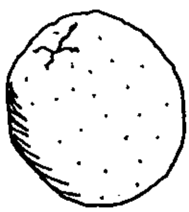
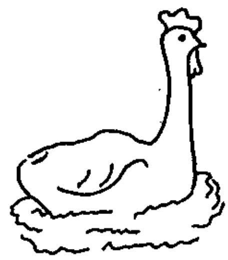
Spelling Posttest:- Study 2

game	moved	trilt
try	young	sked
well	here	swid
room	learn	bist
those	often	grent
simple	heart	fappy
leave	everyone	sned
ship	piece	pont
happen	although	pilt
ran	given	jand
morning	care	nulter
horse	great	saking
help	build	lud
close	nothing	drook
dry	shall	blet
wide	some	prot
hear	Mother	pell
pattern	knew	vannel
best	snow	rether
lay	ready	tave
Spelling Post-test :- 20 Regular Words, 20 Exception Words and 20 Nonwords. (Carroll et al. (1971) 100-550 Most Frequent Words of the Rank Order List, Random Selection)		

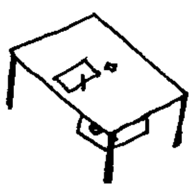
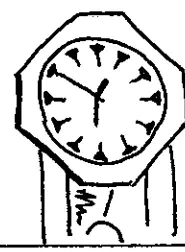
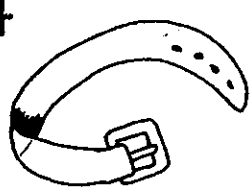
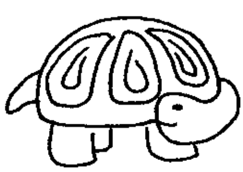
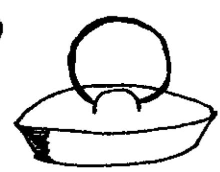
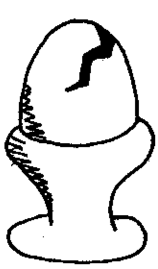
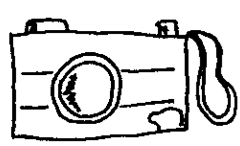
Reading Comprehension Test

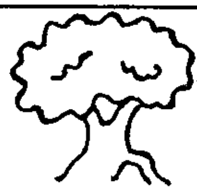
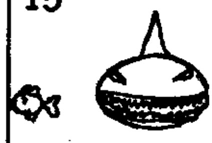
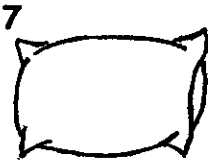
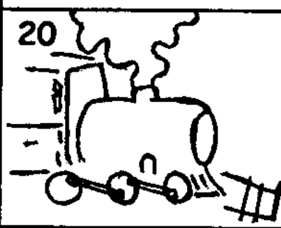
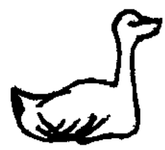
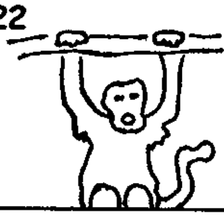
Name.. ☐ Boy ☐ Girl

Grade.................................Date.............. Score RA:

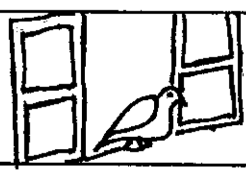
 m o	 v b e	 fin hat hen

Ring the correct letter or word for each question

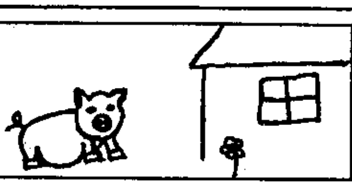
1  h g j	2  e t d	3  f c j
4  r v b	5  q t c	6  p g l
7  i f e	8  a u c	9  z f k

10  van sun rat	11  tap cup cat	12  peg lid leg
13  pick risk ring drill	14  leap tree land track	15  shack what west shark
16  chin chill chair chest	17  post pole pile pillow	18  bank book bottle blue
19  dump dark duck damp dirt	20  train towel truck trail trust	21  snake snail sink sail swan
22  mouse match moon monkey matter	23  contact collar crumbs crumpet computer	24  telephone telegraph transport television travel

25.
A bat can [kit, out, fan, fly, to].



26.
The bird flew in the [water, run, and, window, seat, go].



27.
The little pigs ran to their [leg, down, trunk, song, house, coat].

Twinkle Twinkle

28. Twinkle, twinkle little [site stack stale start sell star strip]

29. How I wonder what you [and ant... art answer asked are]

30. Up above the world so [hill hinge hoist heat high him]

31. Like a diamond in the [space soil sand sky sea sight]

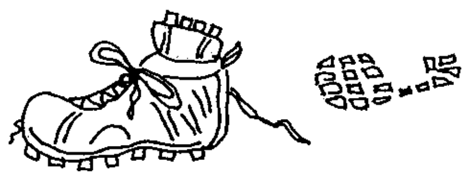
---

32. Ships sail over the sea.
Planes fly through the [bus road path sharp truck air trail]

---

33. "Can we play football", asked Chris.

"Yes", said Dad, "I will bring the ball and the football [oval grass shed bicycle bottle boots be]



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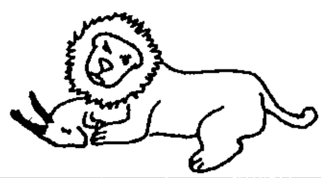
34. Many wild animals come out at night to hunt in the darkness for their [fate bushes fund dreams freedom food fumble]



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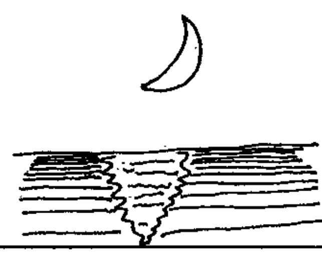
35. The moon was rising over the lake.
David said, "Look at the reflection".
Alex replied, "At night the water is black, with the moon shining its colour is [shiver slower silent silver sombre sort]



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36. Birds make nests but foxes live in [fences huddles hose holes hurdles]

37. After school, the girl ate an [sandwich shake icecream shapes potato chips]

38. All boats have a [there gyrate incident rudder slow lake pride place]
39. A radio has an [plastic electricity off room spoken extension aerial]
40. Vitamins help people to be [beautiful healthy modern loving special important keen]
41. Houses are bigger than [levels castles huts sports palaces metres]
42. Elephants enjoy moving in herds to the rivers where they drink water through their [much bulls ears truncheon trunk trunks tanks calves]
43. Miniature means [height picture sociable wonderful small adequate frantic]
44. A pharmacist would mix [lollies tricksters bottles medicines resistors animals]
45. Water pollution affects the [longitude roads environment travelling clothing low]
46. Some lights work by heating a filament, while fluorescent lights require a [dangerous igneous superficial extroversion digital gas spontaneous]
47. To have sympathy means to have [weakness nausea therapy understanding important agility justice]
48. Microwave ovens cook food by oscillating water [cells temperature pipes taps molecules vibrations sonic solenoids]
49. Telescopes magnify distant objects by using [ladders horizontals lenses sputniks submarines tuberous leads]
50. Bank transactions are carried out under the surveillance of [optometrists militia ingenuity chimeras cameras generators caravans candles]
51 Ultra sonic technology forms images of internal organs by using [fertility aeroplanes barriers cardiac visuals pancreas sounds lobotomy]
52. Computer hackers access other data bases by decoding security [logistical antidotes correspondence demystify communication secrets passwords confidentiality]
53. Immunisation is given to prevent people contracting [disinfectant reaction hypochondria poisonous empathy diseases fungal]
54. The demand for scarce or rare goods will increase their [numbers multiples margins price disguise]
55. An infringement of the rules of a game of sport will incur a [alignment proposition supposition penalty reference injury prestige]
56. A mortgage is finance from a bank in exchange for [certificate property memorabilia registration electronics investigation phosphorous financial]
57. Cloning is the process of injection DNA material into a vacant [stomach sheep ovum fertilization]
58. New laws are made by the Australian parliament in accordance with the [institution abstraction cacophony conditions ceremony constitution national interests]
59. Innate means [indiscrete inedible inborn impose disposable idiotic incandescent incisive]
60. The antonym of aggravate is [fraught assuage collage stimulate dress possess infuriate grip]

Waddington Imitation Spelling Posttest

1.	is	The man is here.	is
2.	cap	He has a cap on.	cap
3.	yet	He is old, yet he enjoys himself.	yet
4.	wax	Bees make wax.	wax
5.	had	The tree had bees in it.	had
6.	jot	He will jot down his thought.	jot
7.	zip	My bag has a zip on it.	zip
8.	vet	A vet can help your sick bird.	vet
9.	frog	The frog sat on the log.	frog
10.	stop	Stop at the red light.	stop
11.	block	Did you buy a block of chocolate?	block
12.	quit	Don't quit trying.	quit
13.	string	Tie string around the parcel.	string
14.	scrub	Scrub the dirt off your shoes.	scrub
15.	camp	Let's camp in the scrub.	camp
16.	mint	I like the taste of mint.	mint
17.	shaft	Gold mines often have a shaft.	shaft
18.	thing	Helping others is a good thing.	thing
19.	smell	They could smell the food.	smell
20.	child	She cared for the child.	child
21.	whisk	Use a whisk on the powdered milk	whisk
22.	patch	Put a patch over the tear.	patch
23.	keep	Will they keep being happy?	keep
24.	park	Play in the park.	park
25.	verb	A 'doing word' is called a 'verb'.	verb
26.	permit	He left his bus permit at home.	permit
27.	report	The girl received a splendid report	report
28.	room	Sit down in the TV room.	room
29.	goat	We saw a goat at the show.	goat
30.	around	The bear walked around his cage	around
31.	tower	Sydney tower is very high.	tower
32.	steam	Steam came from the kettle	steam
33.	brain	Brain cells can not be replaced.	brain
34.	bird	The emu is a flightless bird.	bird
35.	toil	He will toil to finish his work.	toil
36.	hurt	It is better not to hurt others.	hurt
37.	sale	Do you see the 'for sale' sign?	sale
38.	bone	Every chicken has a wish bone.	bone
39.	line	Write your words on the line.	line
40.	tube	Open the tube of tooth paste.	tube
41.	slide	Slide down the slippery dip.	slide
42.	pray	Some people pray at church.	pray
43.	jaw	Teeth grow in your jaw.	jaw
44.	chew	We use our teeth to chew food.	chew
45.	fly	A kookaburra can fly.	fly
46.	floppy	The dog had a floppy tail.	floppy
47.	bright	It was a very bright light.	bright
48.	taught	Mum taught me to walk.	taught

49.	physical	Physical exercise makes you fit.	physical
50.	believe	Believe in what you do.	believe
51.	that	That is a desk.	that
52.	are	We are here.	are
53.	of	He sang of his joy.	of
54.	a	It is a new day.	a
55.	give	She will give her friend a gift.	give
56.	two	Two sparrows flew into the tree...	two
57.	then	...then they flew away.	Then
58.	their	Their twittering could be heard.	their
59.	where	Where did the sparrows go?	where
60.	many	Why are there so many sparrows?	many
61.	one	This is word number sixty one.	one
62.	more	We have a few more words to go.	more
63.	before	.....before we have finished.	before
64.	your	Where is your bag?	your
65.	along	Cars drive along highways.	along
66.	enough	It was enough just to be there.	enough
67.	could	Could the sun shine today?	could
68.	water	Water is essential for life.	water
69.	thought	They thought about their work.	thought
70.	don't	Don't worry, be happy.	don't

Attitudinal Survey Study 2

1. Reading is fun.
2. Reading is too difficult.
3. I can explore the world by reading.
4. Sometimes I feel like giving up on my reading.
5. I like to receive a book on my birthday.
6. All of my classmates can read better than I can.
7. Reading is a useless subject.
8. Reading problems can be overcome with effort.
9. I like reading out loud.
10. Reading makes me nervous.
11. I can get by without reading.
12. My reading will never improve even if I try.
13. I look forward to reading.
14. I can't keep up with the work we do in reading.
15. I can't see why I have to do reading.
16. Good readers don't have to work hard.
17. I read for pleasure.
18. I understand most of the things I read.
19. I need to read to find out about things that interest me.
20. I am determined to be a reader.
21. I enjoy my reading classes.
22. Reading new words is easy.
23. I learn important things in my reading classes.
24. With time and energy my reading will get better.
25. I avoid reading when I can.
26. Reading tests are easy.
27. I can use the things I learn in reading outside of reading lessons.
28. Reading gets easier with practise.

Name

Date Class

Circle one word for each question.
Circle the word that best answers the question for you.
Your answers will not be read by your teacher.
Circle the word for yourself.

1. yes no sometimes

* * * * * * * * * * * *

2. yes no sometimes

* * * * * * * * * * * *

3. yes no sometimes

* * * * * * * * * * * *

4. yes no sometimes

* * * * * * * * * * * *

5. yes no sometimes

* * * * * * * * * * * *

6. yes no sometimes

* * * * * * * * * * * *

7. yes no sometimes

* * * * * * * * * * * *

8. yes no sometimes

* * * * * * * * * * * *

9. yes no sometimes

* * * * * * * * * * * *

10. yes no sometimes

* * * * * * * * * * * *

11. yes no sometimes

* * * * * * * * * * * *

12. yes no sometimes

* * * * * * * * * * * *

13. yes no sometimes

* * * * * * * * * * * *

14. yes no sometimes

* * * * * * * * * * * *

15. yes no sometimes

* * * * * * * * * * * *

16. yes no sometimes

* * * * * * * * * * * *

17. yes no sometimes

* * * * * * * * * * * *

18. yes no sometimes

* * * * * * * * * * * *

19. yes no sometimes

* * * * * * * * * * * *

20. yes no sometimes

* * * * * * * * * * * *

21. yes no sometimes

* * * * * * * * * * * *

22. yes no sometimes

* * * * * * * * * * * *

23. yes no sometimes

* * * * * * * * * * * *

24. yes no sometime

* * * * * * * * * * * *

25. yes no sometimes

* * * * * * * * * * * *

26. yes no sometimes

* * * * * * * * * * * *

27. yes no sometimes

* * * * * * * * * * * *

28. yes no sometimes

* * * * * * * * * * * *

Thank you, have a good day.