

AUDITORY INTERFERENCE AND PHONOLOGICAL ENCODING IN READING FOR  
MEANING

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A thesis submitted to the Faculty of Arts, University of the  
Witwatersrand, Johannesburg, in fulfilment of the requirements  
for the degree of Master of Arts.

Johannesburg 1983

ABSTRACT

The main aim of the present research was to investigate the effects of auditory interfering stimuli and an articulatory suppression task on pre- and postlexical phonological encoding during reading. Sixty undergraduate students performed a Prose Comprehension task (Experiment 1) and a Nonword-rhyming task (Experiment 2) under conditions of INTERFERENCE and NO INPUT. An analysis of covariance and post-hoc t-tests revealed that semantically and syntactically complex verbal auditory input had the greatest interfering effect on the speed of performance of the Prose Comprehension task. No other results were statistically significant. Twenty undergraduate students (Experiment 3) and twenty children (ten dyslexics, ten normal readers - Experiment 4) performed a Magnitude Judgment task under conditions of INTERFERENCE and NO INPUT. Prose auditory interference and an articulatory suppression task did not significantly slow down the performance of skilled readers while prose input did slow down the performance of both dyslexic and normal children. Magnitude Judgment accuracy data was not analysed due to the low error rate. The results of the present research were interpreted within the framework of a neuro-cognitive model of reading based largely on Luria's neuropsychological model of the "working brain" and Morton's "Logogen" model of word recognition.

DECLARATION

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

Joan Christowity

sixth day of December, 1983.



ACKNOWLEDGMENTS

I extend my grateful thanks to:

my supervisor, DR ESTELLE DOCTOR, for being a willing fount of expert knowledge and for her time selflessly given, for her patience, continued interest, encouragement and moral support throughout this research;

DR MICHAEL SALING for his clarity of thought and for many valuable hours of theoretical discussion and practical statistical advice;

PROF. MAX COLTHEART of Birkbeck College, University of London, for information regarding the use of the  $P(\bar{A})$  statistical measure;

the girls of the 1982 WITS PSYCHOLOGY III class, who helped to generate level IV prose auditory stimuli;

JACQUI ISAACMAN and DAPHNE ROSENDORFF who assisted in the preparation of stimuli material and in the running of the experiments;

the WITWATERSRAND TECHNIKON for permission to use wordprocessing facilities, and to MISS ERNA FOURIE who enthusiastically and ably



helped in the editing of this thesis;

STUDENTS and STAFF of the University of the Witwatersrand,  
Glenoaks School, and Impala Primary School for willing  
cooperation and participation in the experiments;

HSRC and UNIVERSITY OF THE WITWATERSRAND SENIOR BURSARY FUNDS  
which financed this research;

GOD, without whose inspiration and continued sustaining power  
this work would have been neither begun nor completed.

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CHAPTER ONE: INTRODUCTION

"...a real understanding of language will not be achieved until we have a reasonable notion of its neurological mechanisms"  
(Geschwind, 1976, p.88).

"It is necessary to try to describe levels of the organization of language rather than to look for their localization"  
(Dimond, 1980, p.327).

Geschwind's (1976) statement regarding language is equally applicable to reading. However this claim must be tempered by Dimond's (1980) argument. In the light of these statements the present research aimed at striking a balance between a cognitive approach to reading and relevant neuropsychological studies and theory by studying the effect of auditory interference on the reading process.

"The integration of these insights should be mutually beneficial, and provide a theoretical framework that is capable of reflecting the complexities presented by the functional organization of the brain"  
(Philips, 1982, p.21).

In a review of reading research reports between 1900 and 1975, Bruton (1977) has pointed to a number of flaws inherent in much reading research. In particular, he mentions that reading research is often inadequate due to:

- i) flaws in the design of the studies,
- ii) the majority of studies being correlational rather than experimental in nature,
- iii) there being no experimental basis for the more prevalent definitions of reading,

iv) the fragmentary nature of the experimental research on reading comprehension that does exist.

In the present research an attempt was made to overcome these flaws.

The central question investigated by the present research was the role of phonological encoding during silent reading for meaning. Although the phenomenon of "inner speech" (Huey, 1908) during silent reading has been referred to and studied from the time of the earliest research into the reading process, its exact nature and role in reading remains controversial. There are numerous studies purporting to examine "inner speech" processes in reading, but no single precise definition of phonological encoding has emerged. At most, such studies have identified certain characteristics of "inner speech" which are reflected in the names given to this process by various researchers. Baddeley (1979) has referred to an "articulatory code", presumably based on the covert articulation of the printed word, and used to "hold" a particular "chunk" of information which has been read in a temporary memory buffer store while the next "chunk" of information is processed. There is evidence from studies of short-term memory ( Craik & Levy, 1970; Crowder, 1978) for the existence of an "acoustic" or "auditory" code which facilitates the serial recall of letter strings, particularly when such letter strings are not acoustically confusable (e.g. m q r s t ). Baron (1977) has referred to "phonemic recoding" whereby the letters of a printed word are translated into their corresponding phonemes. This definition is the one which most

closely approaches the definition of "phonological encoding" as it is used in the present research.

In the present research "phonological encoding" refers to the process whereby the printed word is translated into an abstract phonological/phonemic equivalent. It may occur at syllabic level or at the level of the whole word. It involves the use of the auditory equivalent of the printed word but is not identical with the "auditory" or "acoustic" codes referred to earlier. Phonological encoding may take place prior to the accessing of word meaning in the internal lexicon, or after lexical access has occurred, depending on the demands of the task.

Several authors have addressed the question of what role phonological encoding plays in the reading process. Some researchers (e.g. Levy, 1975; Rubinstein, Lewis, & Rubinstein, 1971) claim that phonological encoding is essential to all reading. Others (e.g. Baron, 1973; Bower, 1970) claim that reading is a purely visual process and that phonological encoding may in fact slow or hinder reading. Yet others (e.g. Coltheart, 1978; Meyer & Ruddy, 1973; Morton, 1979) present "dual-processing" models of reading which assume that both visual and phonological routes to the internal lexicon exist and are used according to the demands of the reading task. The present research adopts a "dual-processing" approach to the study of reading, and in accordance with Forster and Chambers (1973) distinguishes between the use of phonological encoding prior to lexical access (prelexical or nonlexical phonological encoding)



and after lexical access (postlexical phonological encoding).

Many studies have attempted to investigate the process of phonological encoding during reading by interrupting, blocking or interfering with it. The major source of interference thus far has been the use of an articulatory suppression task. It has been assumed that the "inner speech" which occurs during reading is related to "outer speech" and will hence be interrupted by a task which, for example, requires the subject to repeatedly say a word (e.g. "the" or "bla"), or "shadow" a list of digits out loud, while simultaneously performing a reading task. Results of studies using the articulatory suppression task have been inconclusive and contradictory. In the present research the inadequacy of the articulatory suppression technique was discussed, and auditory input (verbal and non-verbal) was used to interfere with phonological encoding during reading.

Not only the articulatory suppression tasks, but also the reading tasks employed in previous studies investigating phonological encoding and the reading process, have often been inadequate. Rather than using tasks directly involving the entire process of extracting meaning from the printed word, most previous research has employed simple tasks involving isolated aspects of the reading process, for example, visual word and pattern recognition, lexical decision tasks, or short-term memory tasks. It has been assumed that if phonological encoding is necessary to one of these processes, then, because these processes are involved in reading, it must play a similar role in the reading

process. However, this assumption may be illfounded. Although word recognition, lexical decision and short-term memory are important aspects of reading, the reading process as a whole is more than the sum of its constituent processes. Thus the tasks used in the present research involved the entire reading process, rather than the isolated processes which constitute reading. Tasks involving both prelexical or nonlexical phonological encoding (nonword-rhyming), and postlexical phonological encoding - with a memory load (prose comprehension) and without a memory load (magnitude judgment) - were used.

With respect to the practical implications of the present research, there have been suggestions that developmental dyslexics experience difficulties in the use of phonological encoding during reading, but few empirical studies or conclusive results have been forthcoming. Some researchers (e.g. Hulme, 1981) have argued that dyslexics rely too heavily on the visual route to meaning during reading, while others (e.g. Barron, 1981) have argued that dyslexics' difficulties arise from an over-reliance on phonological encoding while reading. Still others (e.g. Boder, 1971) argue that three groups of dyslexics exist: those who have difficulty in using a phonological encoding route to meaning, those who rely too heavily on phonological encoding during reading, and those who have difficulty in using both visual and phonological routes to meaning. The aim of part of the present research was to investigate phonological encoding by developmental dyslexics. If the nature of dyslexics' difficulties in using phonological encoding during reading could

be specified, remediation that involves training dyslexic children in the appropriate use of phonological encoding during reading could be implemented.

## CHAPTER TWO: PHONOLOGICAL ENCODING AND READING

The presence of "inner speech" (Huey, 1908) during silent reading is a phenomenon much reported in the literature, but the exact role played by phonological encoding in the process of extracting meaning from the printed word remains a controversial issue.

It is likely that children learn to read by linking the sounds of words in their already well-established aural vocabulary with their graphemic representations in print:

"If the beginning reader is to take greatest advantage of an alphabet and of the language processes he already has, he must convert print to speech or, more covertly, to the phonetic structure that in some neurological form must be presumed to underlie and control overt speech articulation"

(Lieberman, Shankweiler, Liberman, Fowler, & Fischer, 1977, p.207).

However theories regarding the role of phonological encoding in the acquisition of reading skills have been contradictory.

Geschwind (1974) claimed that:

"There is some clinical evidence that beginning reading processes are more dependent on visual perception than on auditory abilities ... By contrast reading success at later stages, when analysis becomes necessary, is more dependent on auditory than on visual perception"  
(p.271-2).

There has been evidence in the literature supporting Geschwind's (1974) statement. For example, Barron and Baron(1977) tested children in the first through the eighth grade on a word-picture matching task. Subjects had to say whether the items rhymed, in a sound task, or "went together" in a meaning task. A concurrent



articulation task (repeating the word "double") interfered with the sound task but not with the meaning task across all age groups. The authors concluded that all children can get meaning from printed words directly, without the use of an intervening phonemic code. Although this study does not support Geschwind's (1974) argument in favour of a developmental switch from the use of a visual reading strategy to the use of an auditory code, it does provide some evidence for the use of a visual reading strategy by young readers.

On the other hand, evidence for the use of phonological encoding by beginning readers has been more prevalent. Liberman et al. (1977) investigated phonetic segmentation and recoding in beginning readers. They argued that while phonemic recoding is a difficult skill for children to acquire, it is necessary to enable them to read novel words. Learning new words by a "whole word" method is slow and stretches storage capacity beyond its limits; each new word has to be learnt as if it were completely novel. However the use of phonemic segmentation and recoding enables children to draw on their existing knowledge of sounds and letters and, at least to the extent that the novel words have regular grapheme-phoneme correspondences, is more economical. To test this argument, Liberman et al. investigated the performance of good and poor beginner readers on a task requiring the serial recall of letter strings which were either phonetically confusable, e.g. b c d g t, or phonetically nonconfusable, e.g. h k l q r. They found that in general good beginning readers made fewer errors than did poor beginning readers. Although

phonetic similarity of the letters in a letter string caused some deterioration in the recall performance of all children, this similarity effect was greater for the good readers than for the poor readers. Liberman et al. concluded that good beginning readers made greater use of a phonological code in performing the task than did poor readers, and that "phonemic recoding" is thus essential to proficient reading. However this conclusion is not wholly justifiable due to methodological flaws in the study - the letter strings used, e.g. b d p g, were not only phonetically confusable but also visually confusable. Moreover it is doubtful whether the conclusion reached here on the basis of a short-term memory task may be generalized to the complex skilled reading process.

Bradley and Bryant (1983) have provided further evidence of a link between children's phonological awareness and reading. They conducted a longitudinal study whereby they measured children's skills at sound categorization before they had started to read and related these to their progress in reading and spelling over four years. The children's ability to categorize sounds was assessed by means of a task requiring them to identify the "odd" sound in a list of 3 - 4 words per trial all but one of which showed a common phoneme. A subsample of the group participating in the longitudinal study was also given training in sound categorization. The results obtained revealed a definite positive relationship between children's skill in categorizing sounds and their success in reading and spelling at the end of the four year period. Although this study has indicated that the

ability to make phonological judgments is an important pre-reading skill it did not directly tap the process of phonological encoding during reading by children.

Doctor (1981) and Doctor and Coltheart (1980), using tasks more representative of the actual reading process at both single word and sentence level, have shown that while young children between the ages of 5 and 7 years rely heavily on phonological encoding while reading silently for meaning, this reliance on phonology diminishes with age and reading skill. Younger children made far more false positive responses in judging whether sentences such as I HAVE KNOW TIME are meaningful, than did older children and adult skilled readers. Such errors could not be attributed to poor spelling or visual similarity between the incorrect word in the sentence and its correct counterpart.

To summarize, the exact role played by phonological encoding in the reading process remains a controversial issue. It is likely that children learn to read by linking the sounds of words in their already well-established aural vocabulary with the printed word, but theories regarding the role of phonological encoding in the acquisition of reading skills have been contradictory. Some researchers (e.g. Barron & Baron, 1977; Geschwind, 1974) have argued in favour of the use of a purely visual reading strategy by young readers. However there has been more evidence in the literature (e.g. Bradley & Bryant, 1983; Doctor, 1981; Doctor & Coltheart, 1980; Liberman, et al., 1977) in favour of the use of some form of phonological encoding during reading by proficient

beginning readers.

With regard to the role of phonological encoding in silent reading for meaning by skilled adults, some researchers have argued that phonological encoding is essential to all reading. Others have argued for its redundancy. Still others have proposed "dual-processing" models, according to which phonological encoding is differentially employed depending on the nature of the reading task. The relevant literature will now be reviewed.

### 2.1 Phonological encoding is essential to reading

This view is held by those who assume that the process of phonological encoding is central to all reading. In a seminal paper, Rubinstein, Lewis, and Rubinstein (1971) have argued for the essential role of "phonemic recoding" in visual word recognition, which, it is assumed, is a central part of the reading process. A lexical decision task\* was used, which involved a subject's responding by pressing a YES key when a single letter string presented to him on a computer screen was a legitimate English word\*, or a NO key when the letter string was not an English word. Rubinstein et al. found that decision latencies were longer if nonwords\* were orthographically legal\* and pronounceable and/or homophonic\* to English words. This

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\* All terms marked with an \* are defined in the GLOSSARY p.159.



supports their hypothesis that phonological encoding takes place even when the word is presented visually. They also postulated that such encoding occurs simultaneously with the initial perceptual analysis of a word into its graphemes\*, and that the phonological representation of the word is used for lexical access\*. However their findings do not rule out the possible existence of a visual lexical access route. Illegal and unpronounceable nonwords may be rejected on the basis of their illegal orthographic representations\*, prior to lexical access, while a visual route may be used to access legitimate English words. Furthermore, caution must be exercised in the interpretation of the results of this study due to a number of inherent methodological flaws. Coltheart, Davelaar, Jonasson, and Besner (1977) have identified three such flaws in Rubinstain et al's study, namely:

i) "Their YES effect is not significant using statistj analyses which treat both subjects and words as random effects (Clark, 1973). This means that their conclusion that less frequent homophones have long YES times may not be generally true for all subjects and all homophones". (Coltheart et al., 1977, p.542);

ii) The majority of homophones used were less frequent ones, and the non-homophonic words with which they were compared were not matched in terms of word frequency, part of speech, or number of letters;

iii) visual similarity between words and nonwords was not controlled for.

Also, the error data was not analyzed and thus the possibility of a speed-accuracy trade-off could not be investigated. Furthermore, the simple nature of the experimental tasks used by Rubinstein, et al. may not allow the generalization of their conclusions to more complex reading tasks.

Parkin (1982) also used a lexical decision task to investigate the role of phonological encoding in reading. Half of the English words used were regular\* while the other half were words with irregular grapheme-phoneme correspondences ("exception" words). Although each regular word (e.g. grill) was matched with an exception word (e.g. grudge) in terms of frequency of occurrence, part of speech, number of letters and number of syllables, no attempt was made to control for visual similarity between the words. Also, no attempt was made to control for visual similarity between the English words and their nonword counterparts. Parkin found that decision latency for "exception" words was longer than for regular words and concluded that:

"these results indicate the existence of a phonological recoding stage in reading" (p.43)

He also argued that the units involved in such phonological encoding may be larger and more wholistic than single graphemes. That is, encoding of the word into its phonological equivalent may involve the use of phonology after the initial sensory registration of the combination of single graphemes which constitute the word. These conclusions may not be entirely

valid, however, due to Parkin's failure to control for visual similarity of the words and nonwords used, and his failure to include and comment upon the nonword latency data. Furthermore, the assumption that because phonological encoding appears to be essential to the lexical decision element of the reading task, it is also essential to the reading process as a whole, may not be valid.

Other researchers have used different experimental procedures to demonstrate the necessary role of phonological encoding in reading. Springer (1976) used a semantic comparison task to investigate phonological encoding during reading. One group of subjects was sequentially presented with visual word triads in which the first two words were heterophones\* or unrelated controls, while a second group viewed rhyming words or unrelated controls. The subjects were required to press either a YES key or a NO key depending on whether or not the third word of the triad was synonymous with either of the first two words. Reaction times to both "heterophone" and "rhyme" triads were slower than reaction times for the "control" triads. However, there was a significant interaction effect between the rhyme versus heterophone manipulation and the YES/NO factor. Springer argued from this result that phonological encoding took place, and was used in lexical access. However methodological flaws in the study render this conclusion tentative. As in Parkin's (1982) study, discussed above, visual similarity was not controlled for - it is not stated whether or not the "rhyme" triads contained words which were similar in spelling. Also it



is not clear from the task whether lexical access was achieved by means of a phonological encoding route (as Springer argues) or by means of a visual route. Access to the lexicon may, in fact, have been achieved by a visual route. The phonological information stored with the semantic information about the word could then have produced the heterophone and rhyming interference effects.

Haber and Haber (1982) have argued in favour of the use of a phonological strategy in reading, but their study is also limited by methodological flaws. They demonstrated that in both "out-loud" and silent reading conditions subjects took longer and made more errors in reading tongue twisters than in reading control sentences. However, their study does not rule out the possibility that visual rather than phonological confusability of words in tongue twisters (e.g. WHICH WITCHES WISHED WICKED WISHES?) caused their reading to be slower than that of control sentences (e.g. WHICH PILOTS FLEW HEAVY BOMBERS?). The task also did not specifically require accessing of the semantic lexicon as comprehension of the sentences and tongue twisters was not tested. If in performing the task the subjects did access the meanings of the sentences, the semantic obscurity of the tongue twisters could have resulted in their being read more slowly than the less obscure control sentences. Moreover, Haber and Haber do not comment on the specific role of phonological encoding in reading.

The studies reviewed thus far have employed fairly simple or



artificial reading tasks (e.g. reading of single words, word recognition, lexical decision tasks, reading of tongue twisters). Few studies have been devised in which the experimental task mirrors the process of reading connected discourse for meaning. One such study however, is that of Levy (1975). She used a task which closely approximated normal skilled reading of complex prose and demonstrated that concurrent articulation\* effected a decrement in recall of thematically related sentences. This decrement in performance was greater when sentences were presented visually than when they were presented auditorily. Levy concluded that: "the data here support the view that speech-motor activity plays a useful information processing role during reading" (p.314), but stressed the tentative nature of this conclusion. She also allowed for the possibility that the necessary role of "speech-motor activity" in the performance of her particular reading tasks, as linked with phonological encoding, may not be generalizable to the reading process as a whole.

To summarize, studies motivated by the view that phonological encoding is essential to reading have been reviewed in this section. Many of these studies have been methodologically flawed by a failure to control for word frequency (Rubinstein, et al., 1971) or for visual similarity between task stimuli (Haber & Haber, 1982; Parkin, 1982; Rubinstein et al., 1971; Springer, 1976). Not all the studies report both error and latency data and therefore the possibility of speed-accuracy trade-offs cannot be discounted. Also these studies, while purporting to

artificial reading tasks (e.g. reading of single words, word recognition, lexical decision tasks, reading of tongue twisters). Few studies have been devised in which the experimental task mirrors the process of reading connected discourse for meaning. One such study however, is that of Levy (1975). She used a task which closely approximated normal skilled reading of complex prose and demonstrated that concurrent articulation\* effected a decrement in recall of thematically related sentences. This decrement in performance was greater when sentences were presented visually than when they were presented auditorily. Levy concluded that: "the data here support the view that speech-motor activity plays a useful information processing role during reading" (p.314), but stressed the tentative nature of this conclusion. She also allowed for the possibility that the necessary role of "speech-motor activity" in the performance of her particular reading tasks, as linked with phonological encoding, may not be generalizable to the reading process as a whole.

To summarize, studies motivated by the view that phonological encoding is essential to reading have been reviewed in this section. Many of these studies have been methodologically flawed by a failure to control for word frequency (Rubinstein, et al., 1971) or for visual similarity between task stimuli (Haber & Haber, 1982; Parkin, 1982; Rubinstein et al., 1971; Springer, 1976). Not all the studies report both error and latency data and therefore the possibility of speed-accuracy trade-offs cannot be discounted. Also these studies, while purporting to

demonstrate the existence of phonological encoding during reading, pay scant attention to the actual role or purpose of phonological encoding during reading for meaning. An experimental task sufficiently representative of the complex process of extracting meaning from the printed word was used in only one study (Levy, 1975). The other studies investigated the role of phonological encoding in isolated aspects of the reading process (e.g. reading single words, word recognition, lexical decision tasks, reading of tongue twisters). In the light of these criticisms, it appears that the view that phonological encoding is used by all readers in all reading tasks cannot be accepted without reservation.

McCusker, Hillinger, and Bias (1981) have argued that the question of whether or not a "phonemic" stage is essential in skilled reading may be settled by showing the existence of a group of readers who are unable to make use of indirect recoding to phonology for the purpose of lexical access, or whose use of phonological encoding is in some way curtailed or impaired. Such evidence is available in the form of studies using:

- i) profoundly and congenitally deaf subjects;
- ii) those who have suffered brain damage which has resulted in specific types of alexia whereby grapheme-phoneme translation is seriously impaired;
- iii) other languages (e.g. Chinese and the KANJI script of the Japanese) which employ ideographic "alphabets" and preclude the use

of phonology as a route to lexical access.

Such studies do exist, as do studies where skilled readers perform reading tasks that use a visual lexical access route as opposed to an indirect phonological encoding route. These studies will now be reviewed.

## 2.2 Phonological encoding is not essential to reading

It is apparent from studies of reading by the deaf (e.g. Conrad, 1972; Doctor, 1978; Millar, 1982) that phonological encoding is not essential to reading. While congenitally and profoundly deaf people acquire reading skills with great difficulty and their reading ability seldom reaches a level comparable to that of normal skilled readers, they are nevertheless able to acquire some reading skills despite their never having acquired auditory language. Millar (1982) has provided evidence that "inner speech" can be other than acoustic, and that deaf people can and do make use of a phonological code using articulatory and visual information about oral speech. However there is also evidence in the literature that deaf subjects use a direct visual route to achieve lexical access while reading for meaning. Doctor (1978) studied the reading performance of 36 congenitally and pre-linguistically deaf children on a lexical decision task using short sentences. The study revealed the overall reading performance of the deaf children to be worse than that of hearing children. This finding could be used in support of the argument that phonological encoding is essential to reading. However the



nature of the errors made by the deaf children revealed their ability to read without reliance on phonological encoding. The experimental task was designed to show up errors due to phonological encoding (e.g. the acceptance of such sentences as: HE CARRIED A HEAVY WAIT or HE CARRIED A HEAVY WATE, as meaningful English). The deaf children made no such errors, unlike comparable hearing children.

There is also evidence drawn largely from the literature on acquired dyslexia (or alexia) which demonstrates that reading may proceed without the use of phonological encoding. For example, Heilman, Rothi, Campanella and Wolfson (1979) report a study of three patients with left hemisphere lesions and consequent aphasia who had poor speech comprehension but could comprehend written language. One patient later suffered a right hemisphere lesion which left him unable to read or to use a sign language he had learnt after his initial left hemisphere lesion. From their study of these cases Heilman et al. concluded that in some people the left hemisphere is responsible for grapheme-phoneme translation in reading while the right hemisphere predominantly uses a direct visual route in lexical access. This concurs with Coltheart's (1980) statement that:

"It can be claimed with some confidence that the right hemisphere appears to be entirely unable to convert a printed representation into a phonological representation"  
(Coltheart, 1980, p.350).

However, as in Heilman et al's study, patients with massive left hemisphere brain lesions may still be able to extract meaning

from the printed word using the right hemisphere. Thus, while lesions of the left hemisphere may limit the use of phonological encoding (grapheme-phoneme translation), reading may still take place involving the right hemisphere and the visual lexical access route.

Studies of patients with "deep" dyslexia have provided further support for this assumption that "the phonemic stage" (Baron, 1977) is not essential to reading (e.g. Marshall & Newcombe, 1973; Saffran & Marin, 1977; Shallice & Warrington, 1975, 1980). Saffran and Marin have reported a case of deep dyslexia where the subject retained a relatively large reading vocabulary although she was unable to perform tasks which required grapheme-phoneme conversion (e.g. reading nonwords, recognizing rhyme and homophones, accessing lexical entries from nonword homophonic spellings e.g. "kote"). Thus it appears that phonological encoding is not always essential to reading, although Saffran and Marin have pointed out that some of the difficulties of deep dyslexics are due to the very fact that they cannot perform grapheme-phoneme conversions.

In a study of Japanese deep dyslexics, Sasayama (1980) found that the reading of KANA (syllabic) script was greatly impaired relative to the slight impairment in the reading of KANJI (logographic) script. This finding was used to support the argument that skilled readers may gain lexical access by means of a purely visual lexical access route.

The studies and case histories reported above suggest that phonological encoding is not essential to all reading. Moreover, some researchers have argued that an overreliance on phonological encoding may in fact hinder and disrupt normal reading processes. For example, Marshall (1976) has identified a category of dyslexics ("surface" dyslexics) who rely too heavily on phonological recoding:

"(They) appear to assign meaning to individual words solely via phonological coding of the visual stimulus"  
(Marshall, 1976, p.113).

This is reflected in the fact that they are able to read some nonwords, and their reading errors are phonologically similar to the stimuli. Their overreliance on phonological encoding in reading results in very slow reading and an inability to read words whose grapheme-phoneme correspondences are not regular.

While the evidence that phonological encoding is not essential to reading, has thus far been drawn largely from the literature on acquired dyslexia, there is also support for this hypothesis in studies of normal skilled reading.

Bower (1970) conducted an experiment involving readers skilled in reading Greek. They read passages chosen from a modern Greek newspaper. Some of the passages had been "mutilated" by the substitution of some Greek letters for others (e.g.  $\omicron$  for  $\omega$ ) which altered the visual form of the words while maintaining their sound. He found that the readers took longer to read and to translate the "mutilated" passages. Bower argued that this

was due to the readers' having to transform the "mutilated" words into their sound equivalents via an "auditory-articulatory loop" before they could begin semantic analysis of the passages. This was not necessary when the printed words were written in their normal orthographic form. Although the results obtained may have been confounded by the unfamiliar appearance of the "mutilated" passages, Bower's conclusion that:

"Reading can be, and for skilled readers often is, a visual process" (1970, p.145), has been upheld in subsequent studies of skilled reading.

Baron (1973) concluded that a phonemic translation stage in reading did not necessarily occur between visual and semantic analysis of the printed word, when he found that subjects could decide whether a phrase did not make sense as quickly when it sounded sensible as when it sounded nonsensical. For example, TIE THE NOT was rejected as nonsense as quickly as I AM KILL. If a phonemic stage intervened TIE THE NOT should have been rejected less often or have been responded to more slowly than I AM KILL, as the first sentence is homophonic to the lexically acceptable TIE THE KNOT. However this finding does not rule out the possibility that phonological encoding may be used after lexical access, and that it may serve a different purpose to just enabling the reader to derive meaning from the printed word. Baron also found that visually anomalous phrases such as OUR NO CAR were responded to as quickly as MY KNEW CAR. He argued that this was further evidence for the absence of a "phonemic stage" in reading because MY KNEW CAR phrases, being phonologically acceptable as English (cf. MY NEW CAR) would have been rejected



more slowly than their visually anomalous counterparts were they translated into their sound equivalent. However many more errors were made with the MY KNEW CAR phrases. Thus the possibility of a speed-accuracy trade-off cannot be overruled and Baron's conclusions must be regarded with caution.

In summary, studies involving deaf readers, acquired dyslexics and Japanese readers, as well as normal skilled readers, have been reviewed in this section. The results of studies investigating deaf subjects' use of phonological encoding during reading are not unequivocal. However, it is apparent from at least one study (Doctor, 1978) that at least some congenitally and profoundly deaf people make use of a direct visual lexical access route while reading for meaning. The literature on acquired dyslexia, particularly that on "deep" dyslexia, has revealed that, in the absence of an ability to translate graphemes into phonemes, some form of reading may still occur, which appears to proceed purely visually. Normal skilled readers were also shown to read "by eye" (Bower, 1970) in studies by Bower (1970) and Baron (1973).

McCusker et al. (1981) have suggested that:

"The literature on alexia relevant to the phonological recoding hypothesis seems to indicate that there are separate and distinct brain mechanisms subserving visually mediated reading and phonologically mediated reading"  
(McCusker et al., 1981, p.239).

This has been supported by research into the normal reading process. Alexia research, furthermore, reveals that both

mechanisms are needed for proficient reading. Hence it is apparent that neither the studies arguing for the essential nature of phonological encoding in reading, nor those that regard reading as solely reliant on a purely visual route of lexical access yield models of the reading process sufficiently adequate to explain complex skilled reading. Recent research into the role of phonological encoding in reading has therefore favoured "dual-processing" models of lexical access which regard both visual and phonological encoding methods of lexical access as of equal importance, employed differentially depending on such factors as proficiency of the reader and the nature of the reading task. Before "dual-processing" models of lexical access are discussed it is necessary to consider in more detail the important distinction made in the literature (e.g. Forster & Chambers, 1973) between prelexical phonological encoding, postlexical phonological encoding and nonlexical phonological encoding.

### 2.3 Pre-, Post-, and nonlexical phonological encoding

Forster and Chambers (1973) and Coltheart (1980) have drawn an important distinction between pre- and postlexical phonology and their role in reading. Prelexical phonological encoding refers to the process whereby readers translate graphemes into phonemes prior to lexical access (i.e. before the word's meaning has been accessed in the internal dictionary or lexicon). This indirect

method of lexical access is used by young readers or by some skilled readers pronouncing nonwords, e.g. JEAD, which are, by definition, nonlexical. Postlexical phonological encoding involves the use of phonological encoding after a direct comparison of printed word units with existing prototypes in the lexicon has taken place, e.g. the meaning of the word FEET would be accessed directly, not by means of an initial breakdown of the word into its phonemic components. Frith (1979) makes explicit the prelexical/postlexical distinction in the use of phonological encoding in reading:

"The hypothesis of phonological encoding is unchallenged for explaining how nonsense and unfamiliar words are read ... It seems likely that, in normal reading, sound does not play the role of a conveyor of meaning ... Conrad (1972) has argued convincingly that it is advantageous in terms of how memory works to translate visible language into an acoustic code. Thus, sound must be considered to be frequently involved in reading, but only after meaning has been arrived at, or when meaning could not be arrived at" (p.385).

Funnell (1983) has argued for the existence of a third type of phonological encoding, namely nonlexical phonological encoding, which is used in the reading aloud of nonwords. According to Funnell, the nonword is read by means of translating it into its sound equivalent, nonlexically, and not necessarily by means of breaking down the nonword into single graphemes and using grapheme-phoneme correspondence rules (as was proposed by Coltheart, 1978). In support of this argument, Funnell presented the case history of an acquired dyslexic who could read aloud



nonwords but not single graphemes. However, if nonlexical phonological encoding does exist, it is not clear from Funnell's argument what the difference between prelexical and nonlexical phonological encoding is. Forster and Chambers' term "prelexical" phonological encoding and Coltheart (1978) and Funnell's "nonlexical" phonological encoding could be synonyms for the same process, prelexical applying to the use of phonology by beginner readers and skilled readers reading unfamiliar words, nonlexical applying to the use of phonology in the reading of nonwords.

A few studies exist which clearly show that both pre- and postlexical phonological encoding strategies are used in reading. Doctor (1978, 1981) has demonstrated the use of distinct pre- and postlexical phonological encoding strategies by skilled adult readers. She used a short sentence lexical decision task which incorporated both nonwords and legitimate English words. When a nonword was present in a sentence (e.g. HE CARRIED A HEAVY WATE), the sentence was rejected more rapidly than if a grammatically incorrect sentence contained only English words (e.g. HE CARRIED A HEAVY WAIT). Doctor (1981) argued that this phonology effect was postlexical, i.e. phonology was used after lexical access to "hold" the information in a "working memory". Moreover visual codes must also have been used because errors were not made with every meaningless sentence containing only English words and which sounded correct. Sentences containing nonwords showed no phonology effect because the postlexical phonological encoding stage was never reached. (In the case of a nonword, the nonword



**Author** Christowitz J

**Name of thesis** Auditory interference and phonological encoding in reading for meaning 1983

***PUBLISHER:***

University of the Witwatersrand, Johannesburg

©2013

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