

is read by means of prelexical or nonlexical phonological encoding. As there are no lexical entries for nonwords, lexical access cannot occur. This is sufficient to indicate that the sentence is meaningless, and the sentence is rejected).

Doctor (Doctor, 1978, 1981; Doctor & Coltheart, 1980) has also demonstrated the use of prelexical phonological encoding during reading. She found that young children (5 - 7 years old) made more errors on the sentence lexical decision task described above than did older children (9 - 11 years old) and adults. Such errors were indicative of an overreliance on the sounds of the words and hence on prelexical phonological encoding, particularly with respect to accepting as meaningful sentences which contained nonwords homophonic to legitimate English words (e.g. MY HOUSE IS OVER THAIR).

It has also been argued that at least two phonological codes, serving different purposes, exist. Besner, Davies, and Daniels (1981) have argued in favour of more than one phonological code, and have provided some insight into the actual role which these codes play in reading. Using a rhyming task, they demonstrated that articulatory suppression adversely affected subjects' latency scores on word-rhyming but not on nonword-rhyming tasks, while error rates were equally affected for both words and nonwords. When the task was changed from rhyme judgment to homophony judgment there was no difference in latency or accuracy of response to words as compared with response to nonwords under articulatory suppression conditions. This result was obtained

even where nonwords sounded like real words (e.g. PALLIS). From these results Besner et al. argue that:

"there are at least two different phonological codes. Buffer storage and/or maintenance of phonologically coded information derived from print is affected by suppression; phonological recoding from print for the purpose of lexical access can be carried out without any interference from suppression" (p.415).

"If the text is difficult and requires elaborate syntactic processing or information about specific wording, then comprehension may involve the maintenance of phonological information in a short-term buffer ... Such maintenance may be mediated by an articulatory code that is sensitive to suppression" (p.432).

While most studies that have observed a prelexical/postlexical phonological encoding distinction have found evidence to support this conclusion, a few studies (notably Glushko, 1979) demonstrated that naming latencies to nonwords such as FINT (with its inconsistent orthographic neighbours: PINT, MINT) were slower than latencies to nonwords such as FENT (with consistent orthographic neighbours e.g. RENT, BENT). In the light of this finding Besner et al. (1981) conclude that:

"as currently formulated, the nonlexical grapheme-phoneme conversion route does not allow for any influence from the inconsistent pronunciation of orthographic neighbours. The results of Glushko's experiment, therefore, indicate the current theoretical basis for the distinction between pre- and postlexical phonology is not adequate"

(p.428).

This conclusion is not wholly justifiable, however, in that most of the literature making the prelexical/postlexical distinction relates to silent reading, whereas Glushko's study related to

reading aloud, and this may have biased the subjects' response to the tasks. Even if Besner et al's (1981) conclusion is valid, the prelexical/postlexical distinction is still supportable and continues to be observed in current reading research.

2.4 "Dual-processing" models of lexical access

It is evident that both direct visual and indirect grapheme-phoneme translation routes of lexical access exist. Furthermore, it is assumed that the selection of a particular route is determined by the type of reading task and the level of proficiency of the reader. For example, Scheerer (1978) has proposed that the task dictates the method of lexical access employed:

"It is suggested that mediated semantic access subserves the functions of working memory and precise lexical and/or syntactical retention, while the direct route is employed for context-dependent, preliminary semantic encoding in peripheral vision" (p.364).

McCusker, et al. (1981) have suggested three further assumptions basic to dual-processing models of lexical access:

"The various positions on dual access appear to share some common assumptions. In most, phonological recoding and visually mediated access proceed in parallel. Which representation is ultimately used is determined by which is first to access the correct lexical entry. However, visually mediated access is often assumed to be the more rapid and thus more likely to be the representation of choice"

(McCusker, et al., 1981, p.229).

In the light of these assumptions, the major dual-processing

models of lexical access that have been proposed will now be discussed.

2.4.a Meyer and Ruddy's "horse-race" model

Meyer and Ruddy (1973) and Meyer, Ruddy and Schvaneveldt (1974) have proposed a model of lexical access whereby both a direct visual and an indirect phonological encoding route to meaning may be employed. These routes may be used in parallel, or the one route may be used in preference to the other, depending on which route will allow the most proficient performance of the particular reading task involved. The model may be criticized on a number of points. Specific guidelines as to which route is used when are not provided by the model. However, because the visual lexical access route is the faster of the two, it is assumed that normal skilled readers use this route most often, and only use phonological encoding when the task to be performed demands it. A second criticism which may be levelled at the model is that the distinction between pre- and postlexical phonological encoding, (see Section 2.3 above) is not made explicit. Phonological encoding and visual lexical access routes may not be used in parallel, but may be activated at different stages in the reading process, depending on the nature of the task.

Davelaar, Coltheart, Besner and Jonasson (1978) extended Meyer et al's (1973, 1974) horse-race model to interpret their results

obtained from a nonword homophony judgement task. They proposed that simultaneous graphemic and phonemic encoding occurred but that one route will be favoured at the expense of the other where that route leads to the highest accuracy rate. This extended model also allows for a "visual recheck" system following lexical access.

2.4.b Baron's model

Instead of viewing direct (visual) and indirect (phonological) routes to the lexicon as being in competition with each other, as in the "horse-race" model, Baron (1977) suggested that both routes are used simultaneously and in parallel when accessing the same lexical entry. Baron argued that the use of two routes to the lexicon will not overload the processing capacity of the system because both processing routes are automatized. This model may be criticized, firstly, on the grounds that there is little evidence that one or both lexical access routes is automatized to the extent that it requires no attentional space. This criticism applies particularly in the case of highly complex reading tasks that require a heavy memory load. Furthermore, the assumption that both routes operate in parallel may be illfounded. There may be a link between the two routes whereby the use of the one is affected (changed or primed) by the use of the other. Baron (1977) allows for this possibility:

"In activating one code or representation on the basis of other codes, there may be different paths connecting the relevant sets

of codes"

(p.213).

However he argues that the "different paths" are distinct and separate from each other.

2.4.c Morton's original "Logogen" model

Morton(1968,1969) proposed a model of word recognition which subsequent researchers (e.g. Coltheart, 1978; Coltheart, Davelaar, Jonasson, & Besner, 1977) have applied to reading. A diagrammatic representation of the model is given in Figure 1.

According to the model:

"each word (or free morpheme) in a subject's vocabulary was represented by an independent detector, or logogen, whose function was to collect evidence for the occurrence of that word. Evidence could be accumulated in parallel for each logogen, and additively both from sensory analyzers (visual analyzers in reading) and from the semantic or cognitive system" (Allport, 1979, p.245).

When the amount of information collected by the logogen reaches a certain threshold, the corresponding response is made available. This response either finds immediate expression through the "output buffer" or is fed back into the Logogen system or the context (cognitive/semantic) system via a rehearsal loop. Although the model provides for the concerted use of auditory and visual codes in word recognition, it does not explain the link between the codes or how they actually operate in the reading process. The model also does not provide an explanation for the

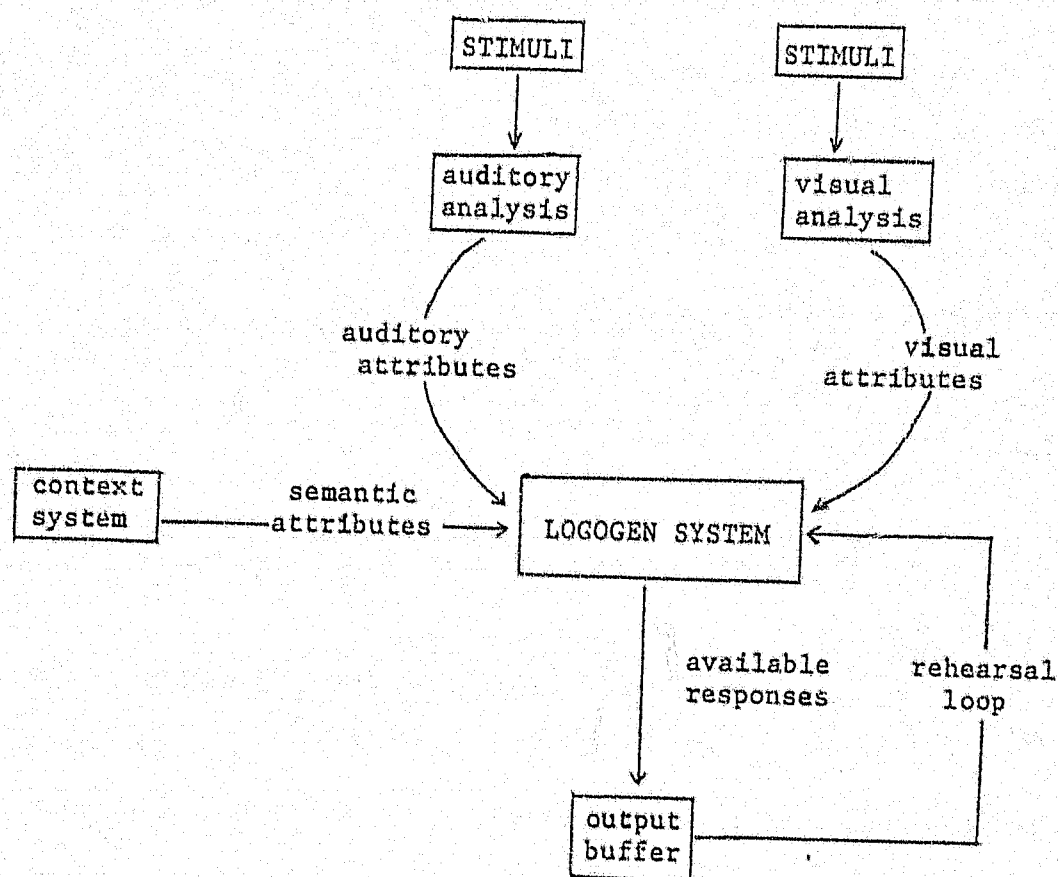


Figure 1. Morton's (1969) Logogen model (taken from Morton, 1969, p.166).

processing of nonwords - nonwords are by definition non-lexical, while logogens only exist for words that have lexical entries.

Coltheart and his associates (Coltheart, 1978; Coltheart, et al., 1977) have applied Morton's (1968, 1969) model to the reading process in general. Their application of this model states that a word's logogen receives activation from both visual and phonological encoding processing and will be recognized when

a certain threshold is reached. When a nonword is processed, it is not recognized because no logogen is sufficiently activated. The model allows for the concerted use of visual and phonological lexical access routes but does not provide an adequate explanation for the use of phonology before and after lexical access. Morton (Morton, 1979; Morton & Patterson, 1980) has more recently modified his model to allow for two separate input logogens and an output logogen, and for greater modality specificity.

2.4.d Morton's revised "Logogen" model

According to Morton's latest modification of his model (Clarke & Morton, 1983; Morton, 1979; Morton & Patterson, 1980), there are two separate input logogens (one visual and one auditory), and one output logogen. Incoming information is analyzed or "recognized" by either of the input logogens, and when the logogen threshold is reached:

"the word can then be produced as a response either through a direct connection to the output system (if such a connection exists) or through the Cognitive System"
(Morton, 1979, p.262).

A diagrammatic representation of this model is given in Figure 2.

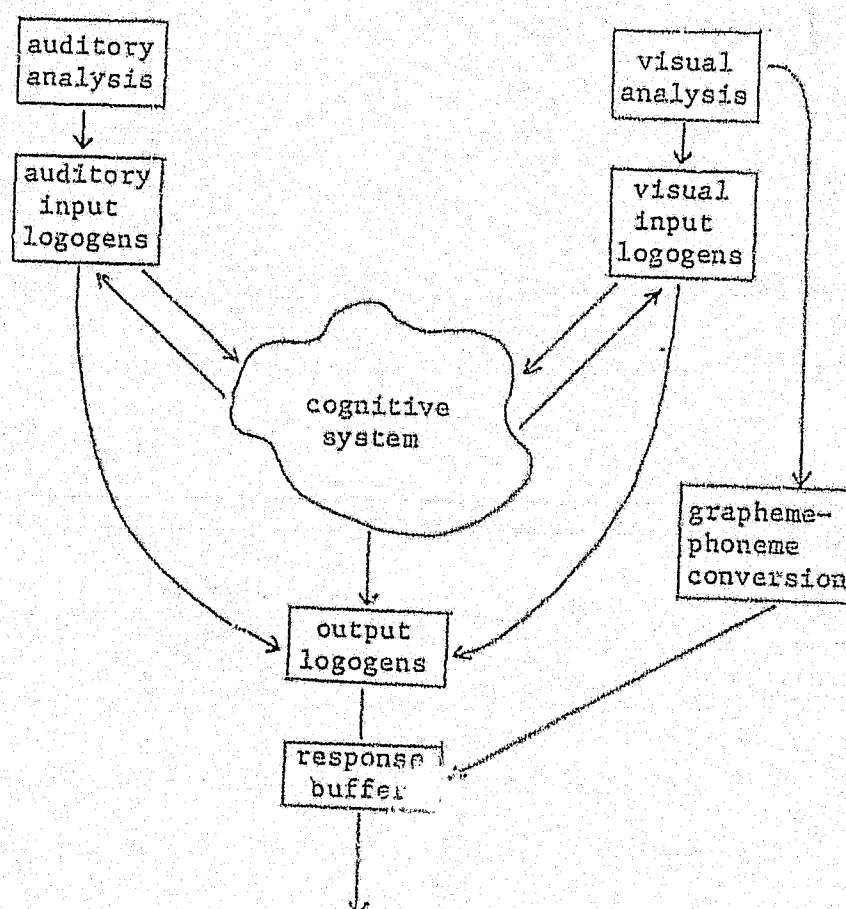


Figure 2. Morton's revised Logogen model (taken from Morton and Patterson, 1980, p.95).

Morton and Patterson (1980) propose that:

- "there are three different ways of obtaining a phonological code given a visual input:
- 1) After categorisation of the stimulus in the visual input logogen, information is sent directly to the output system where the appropriate phonological code is produced.
 - 2) The word is categorised in the visual input logogen system and information is then sent to the cognitive system. Here the appropriate semantics can be found and sent to the output logogen system where the appropriate phonological code could be obtained.
 - 3) The stimulus is treated as a sequence of

graphemes and converted by rule into a phonological code" (p.94).

However, they do not give specific indications as to what the function of each of these codes is. Morton (1979) has described the function of the codes within the Logogen system in that he states that the Logogen system is probably used only for known words. Unfamiliar words and nonwords are initially processed by a system of grapheme-phoneme correspondence rules until they become sufficiently familiar as to be processed by means of the Logogen system. The role of a phonological code within the system is presumably to facilitate grapheme-phoneme conversion. It is also not clear from Morton's model whether similar codes arise from auditory and visual inputs, and how two simultaneous stimuli (one visual and one auditory) would be processed by the system.

In addition to these criticisms, Allport (1979) has pointed out that the Logogen model lacks machinery for perceptual integration, i.e. the putting together of the results of processing from the different domains (input and output logogens and the cognitive/semantic system). It may be that a phonological code is not merely the product of the output logogen system, but also facilitates the integrative processes. In the light of these criticisms, it is of value to examine Baddeley's model of "working memory".

2.4.e Baddeley's model of "working memory"

Working memory comprises two hypothetical components:

"a central executive which is responsible for information processing and decision taking, and an articulatory loop which acts as a slave system, enabling verbal material to be maintained subvocally"

(Baddeley, 1979, p.355).

Baddeley and his associates (Baddeley, 1979; Baddeley & Hitch, 1974) have implicated working memory in the normal reading process. Baddeley (1979) suggested that while beginning readers rely heavily on the articulatory loop in reading, normal skilled readers "may read and comprehend statements without utilization of the articulatory loop" (p.355). However he pointed out a number of conditions under which skilled readers may utilize the articulatory loop. The two most pertinent to the present research are:

- 1) when the task performed requires judgments of phonological similarity, and
- 2) when the task is so complex that the rate of input of material exceeds the rate of semantic processing.

Thus the model proposes that, while phonological encoding is not essential to all normal skilled reading, it may be utilized in tasks which warrant its use.

While this model provides a more functional view of the role of phonological encoding in reading than does Morton's Logogen model, it too may be criticized on a number of points. Firstly, the concept of the articulatory loop has arisen out of memory research, where tasks used, while often linguistic in nature,

have not been sufficiently representative of more complex normal skilled reading to allow large-scale generalization of the model to the reading process. Also, the exact nature of the articulatory loop remains vague: does the loop have direct connexions with articulation (overt or covert)? While the results of experimental investigation of the articulatory loop by means of the articulatory suppression technique (see Chapter 3) have been contradictory and inconclusive, evidence suggests that the loop may not necessarily be articulatory, but may be a more abstract phonemic or phonological code. For example, Vallar and Baddeley (1982), using the Peterson short-term forgetting task, demonstrated that "covert speech is not necessary for rehearsal in short-term verbal memory" (p.53), while a more abstract phonological code may very well play a role in short-term memory.

A further criticism which may be levelled at the model is that it is not clear whether the articulatory loop is merely a "passive" store used to prevent overloading of the "central executive" of short-term memory, or whether it plays an active role in processing of information. Neither does the model clearly define the role of the articulatory loop in lexical access: is it used prelexically or postlexically, or does it have a dual nature, utilizing phonological encoding either pre- or postlexically depending on the nature of the task? Coltheart's (1980) comment is pertinent in this regard:

"At present ... we do not know what relationship there is between phonological encoding as it is operationally defined in working memory experiments and phonological encoding as it is operationally defined in

experiments on lexical access" (p.217-8).

To summarize, it is apparent from the literature that both direct visual, and indirect grapheme-phoneme translation routes to lexical access exist. Several "dual processing" models of lexical access were discussed in this section. Meyer and his colleagues (Meyer & Ruddy, 1973; Meyer et al., 1974) proposed a "horse-race" model, according to which either a visual or a phonological encoding lexical access route may be used in reading, depending on which route will allow the most proficient performance of the particular task involved. Baron (1977) proposed that both visual and phonological encoding routes to the lexicon are used simultaneously and in parallel when a particular lexical entry is accessed. According to Morton's (1969) "Logogen" model, each word in a subject's vocabulary is represented by an independent detector (logogen) whose function is to collect evidence for a particular word. When a certain information threshold is reached, a corresponding response is made available. A later modification of the model (Morton, 1979; Morton & Patterson, 1980) allows for two separate input logogens (one visual and one auditory) and one output logogen. Incoming information is analyzed by either or both input logogens, and when a certain threshold is reached the word can be produced as a response either through a direct connection to the output system or through the cognitive system. Baddeley's (1979) model of "working memory" and the "articulatory loop" was also discussed. According to the model an "articulatory loop" is used to "hold" information when the task performed requires judgments of

phonological encoding in isolated aspects of the reading process (e.g. memory, word recognition), and not complex reading as a whole. Also, most models do not provide adequate guidelines as to the precise nature of phonological encoding and when it is used.

The models and research discussed thus far have dealt largely with the phonological encoding process in relation to normal skilled reading. If phonological encoding is necessary for normal skilled reading, its absence or impairment may lead to reading difficulties. Studies investigating the use of phonological encoding during reading by poor readers will be discussed in the next section.

2.5 Phonological encoding and developmental dyslexia

The exact causes and nature of developmental dyslexia remain a controversial subject at present. However it is apparent from many studies, and in the light of the importance afforded phonological encoding in normal skilled reading, that breakdowns in the use of phonological encoding may account for many problems experienced by developmental dyslexics.

"It is likely that the locus of poor readers' difficulties must lie at least as late in the processing sequence as the activation of phonological or semantic codes"

(Pe ham, 1979, p.1060).

However, the precise nature of such phonological encoding breakdowns remains obscure at present.

Curtis (1980) attempted to forge a link between poor readers' proposed attentional deficits and their verbal comprehension difficulties:

"Less skilled readers' verbal coding processes, because they are slow, require more attention for completion than those of skilled readers. As a result, less skilled readers have less attention available for carrying out the higher level processing necessary for comprehension of what is read" (p.667).

Young and Ellis (1980) investigated the asymmetry of cerebral hemispheric function in normal and poor readers, and found a difference between normal and poor readers in the organization of cerebral functions involved in the processing of visually presented linguistic stimuli. They attributed this difference in lateral asymmetry for word naming between normal and poor readers to the different extents to which the two groups relied on spelling-sound conversion rules or lexical knowledge, rather than to an anatomical or functional difference between the groups in their organization of cerebral functions.

From this it appears that the problems experienced by dyslexics are due in large part to breakdowns in their use of verbal encoding strategies. It is therefore of value at this point to discuss in more detail those studies which have dealt specifically with the use of phonological encoding in reading by poor readers.

Swanson (1978) demonstrated that poor readers performed no

differently from normal readers on a task requiring nonverbal visuospatial short-term memory (the recall of meaningless shapes). However the normal readers performed significantly better than did dyslexics when a verbal encoding strategy was used to aid recall (meaningless shapes were linked with word "names"). Swanson argued that this discrepancy in performance revealed a verbal encoding deficit in dyslexics rather than a visuospatial memory deficit. This conclusion may be criticized however in that the task was not specifically a reading task, preventing generalization of the results. The possible existence of a verbal encoding breakdown in the reading of dyslexics thus remains relatively unexplored. It is therefore necessary to examine studies which have dealt specifically with verbal encoding and reading by dyslexics.

Jorm (1979) has observed that developmental dyslexics have difficulty in accessing the meaning of written words via phonological encoding, although they can successfully access meaning by a direct visual lexical access route. He also states that this phonological encoding deficit is indicative of a short-term auditory-verbal deficit while long-term memory remains intact.

Shankweiler, Liberman, Mark, Fowler and Fischer (1979) have further pinpointed the difficulty in verbal encoding experienced by poor readers by stating that whatever the route of lexical access (indirect phonological encoding or direct visual access), poor readers experience difficulty in the use of phonological

encoding in working memory. This was demonstrated by the fact that poor readers were less susceptible to phonetic confusability in a short-term memory task requiring the recall of strings of random letters than were good readers. However they do not exclude the possibility that for some dyslexics the difficulty may not lie in phonological recoding from the printed word alone, as it was demonstrated that poor readers have difficulty in accessing or using a phonetic representation of a word whether its origin was print or speech. Their conclusion may also be limited in that their "poor reader" group did not consist of dyslexics but of those children falling at the lower end of the normal reading spectrum.

Barron (1981) also used a sample consisting of superior and poor normal readers, and drew attention to the difference between "poor" and "skilled" readers in the use of visual and phonological encoding lexical access routes. He argued that while poor readers may experience breakdowns in the use of either the visual access route or the phonological route, the majority experience difficulty in the use of phonological encoding. (This is in keeping with Petrauskas', 1978, finding that the largest group of dyslexics, identified by means of a neuropsychological test battery, were those with a clear deficiency in auditory-verbal and language-related skills).

In summary, the exact nature and causes of developmental dyslexia remain controversial. Some researchers (e.g. Curtis, 1980; Swanson, 1978; Young & Ellis, 1980) have suggested that

encoding in working memory. This was demonstrated by the fact that poor readers were less susceptible to phonetic confusability in a short-term memory task requiring the recall of strings of random letters than were good readers. However they do not exclude the possibility that for some dyslexics the difficulty may not lie in phonological recoding from the printed word alone, as it was demonstrated that poor readers have difficulty in accessing or using a phonetic representation of a word whether its origin was print or speech. Their conclusion may also be limited in that their "poor reader" group did not consist of dyslexics but of those children falling at the lower end of the normal reading spectrum.

Barron (1981) also used a sample consisting of superior and poor normal readers, and drew attention to the difference between "poor" and "skilled" readers in the use of visual and phonological encoding lexical access routes. He argued that while poor readers may experience breakdowns in the use of either the visual access route or the phonological route, the majority experience difficulty in the use of phonological encoding. (This is in keeping with Petruskas', 1978, finding that the largest group of dyslexics, identified by means of a neuropsychological test battery, were those with a clear deficiency in auditory-verbal and language-related skills).

In summary, the exact nature and causes of developmental dyslexia remain controversial. Some researchers (e.g. Curtis, 1980; Swanson, 1978; Young & Ellis, 1980) have suggested that

dyslexics' reading problems arise from the slowness of their verbal encoding processes, and their over- or underreliance on spelling-sound conversion rules or lexical knowledge. More specifically, other researchers (Barron, 1981; Jorm, 1979; Shankweiler, et al., 1979) have pointed to dyslexics' inefficient use of phonological encoding for the purpose of lexical access. Studies pertaining to these issues were discussed in this section and methodological flaws in : in some of these studies were highlighted.

2.6 General summary and implications

In this Chapter, studies which have investigated the role of phonological encoding in reading have been reviewed.

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 by means of phonological encoding (Bradley & Bryant, 1983; Doctor, 1981; Liberman et al., 1977). Other researchers (Barron & Baron, 1977; Geschwind, 1974) have argued that children can get meaning from printed words by means of a direct visual route to the lexicon, without using an intervening phonemic code.

With regard to the role of phonological encoding in silent reading for meaning by skilled adults, the views of Haber and Haber (1982), Levy (1975), Parkin (1982), Rubinstein, et al.

(1971) and Springer (1976), who maintain that phonological encoding is essential to all reading, were discussed. The opposing point of view, that phonological encoding is not essential to all reading, as proposed by Baron (1973) and Bower (1970), was also evaluated. The observation that reading can take place where the ability to use phonological encoding is limited or impaired, in some deaf subjects and "deep" dyslexics, or cannot be used, as in the case of Japanese readers reading the logographic KANJI script was also discussed.

One outcome of this debate between the use of a purely visual or a purely phonological route of access to the lexicon has been the emergence of a number of "dual-processing" models of lexical access, and some of these were evaluated, for example, Meyer and Ruddy's (1973) "horse-race" model; Baron's (1977) model according to which both visual and phonological encoding lexical access routes are used simultaneously and in parallel; and Morton's (1969, 1979) "Logogen" model.

The conclusion to be drawn from the aforementioned research is that while reading can proceed visually or by means of phonological encoding, it is apparent, particularly in the light of recent research on alexia, that both visual and phonological encoding lexical access routes are needed for proficient reading. Any investigation of the reading process should thus take account of these two methods of retrieving information from the lexicon.

Since both a visual lexical access route and pre- and postlexical

phonological encoding are necessary for proficient reading, it follows that misuse or impairment of any or all of these processes could lead to reading difficulties. Studies demonstrating this were discussed (Barron, 1981; Curtis, 1980; Jorm, 1979; Shankweiler, et al., 1979; Swanson, 1978; Young & Ellis, 1980).

In the light of methodological flaws inherent in many of the studies discussed, it was deemed necessary in the present research: to control for word frequency and visual similarity where isolated letter strings were to be used as stimuli; to record both error and latency data to safeguard against a speed-accuracy trade-off; to examine the actual role or purpose of phonological encoding during reading for meaning; and to employ an experimental task sufficiently representative of the complex reading process in which meaning is extracted from the printed word. Also, in the light of the distinction drawn between prelexical and postlexical phonological encoding (Forster & Chambers, 1973), the tasks which were used in the present research to demonstrate phonological encoding during reading, tapped either prelexical or postlexical phonological encoding.

CHAPTER THREE: INTERFERING WITH PHONOLOGICAL ENCODING IN READING

The phenomenon of phonological encoding in reading has sometimes been investigated by the use of groups of subjects whose use of phonological encoding in reading is in some way impaired or curtailed (e.g. the deaf or braindamaged). In other studies various phonological processes which are assumed to play a part in reading have been examined. An attempt has been made in many of the latter studies to interrupt phonological encoding by means of interference tasks.

Reading tasks which are assumed to involve phonological encoding have been listed by Besner, Davies, and Daniels (1981). These include:

- i) homophony and pseudohomophony (e.g. Barron, 1979; Coltheart, Davelaar, Jonasson & Besner, 1977; Davelaar, Coltheart, Besner & Jonasson, 1978; Rubinstein, Lewis & Rubinstein, 1971),
- ii) syllable effects (e.g. Forster & Chambers 1973),
- iii) letter length effects (e.g. Forster & Chambers, 1973),
- iv) regularity of grapheme-phoneme correspondence (e.g. Coltheart, Besner, Jonasson & Davelaar, 1979; Meyer, Schvaneveldt & Ruddy, 1974),
- v) phrase evaluation and lexical decision tasks (e.g. Baron, 1973; Doctor & Coltheart, 1980),
- vi) concurrent articulation (e.g. Baddeley, 1979; Baron, 1977; Barron & Baron, 1977; Hulme & Ryder Richardson, 1981; Kleiman, 1975; Martin, 1978)." (p.416).

The method of interrupting phonological encoding by concurrent

articulation, coupled with appropriate reading tasks, is by far the most prevalent and controlled method employed in the study of phonological encoding and will be examined in detail.

3.1 Concurrent articulation and reading

The method of interrupting the process of phonological encoding that has been used in most studies has been the articulatory suppression task technique. According to this method the subject performs a reading task while concurrently saying a word out loud (e.g. "double" - Barron & Baron, 1977, or "bla" - Martin, 1978) over and over for the duration of the task. Other tasks have involved the repetition of a series of numbers (e.g. Baddeley, 1979), or "shadowing" a string of digits or sounds (e.g. Kleiman, 1975). Results of experiments involving the use of articulatory suppression methods have been inconclusive and contradictory.

The experimental task used by Barron and Baron (1977) has been described earlier (see Chapter 2). The task involved children at different age levels reading words paired with pictures and deciding whether or not the items rhymed, in a sound task, or "went together" in a meaning task. The tasks were carried out with articulatory suppression (repeating the word "double") and without suppression. The articulatory suppression resulted in no decrement in performance at any age level when the task required meaning judgment. When the task required sound judgment, there was a slight increase in error rate under articulatory

suppression as opposed to no interference, but a similar performance decrement was not observed in the latency data.

In accordance with Barron and Baron's results, Baddeley, Eldridge and Lewis (1981) have shown that articulatory suppression tasks (the continuous repetition of the word "the") resulted in an increase in the number of errors a skilled reader makes in detecting word order errors and semantic anomalies in sentences. Latency remained unaffected by the suppression task.

Kleiman (1975), on the other hand, found that his articulatory suppression task reduced the speed with which skilled subjects could judge whether or not two printed words rhymed to a greater extent than it reduced the speed of judging whether or not the words were visually similar or synonymous. Judgments of whether or not sentences were semantically acceptable were also retarded by the articulatory suppression task.

In contradiction to Kleiman's (1975) results, Baddeley (1979) found that articulatory suppression (repeatedly counting from 1 to 6) per se had no effect on the time taken to judge whether or not printed sentences were true or false, but when the suppression involved an added memory load, the true/false judgments were slowed down. Coltheart's (1980) statement that:

"provided one's technique for suppressing articulation does this and nothing else, and provided the primary task given the subject is close enough to a reading comprehension task, then suppression of articulation has no effect on the reading comprehension of skilled readers"

(p.214-5)

may be used to reconcile Kleiman's (1975) results with Baddeley's (1979) results.

The inconclusive and contradictory nature of these results may also be explained, in part, by the inadequacy of the articulatory suppression technique as a means of interrupting the process of phonological encoding. This technique is inadequate on two counts, namely: the faulty theoretical logic underlying its use, and the simplistic nature of the tasks used.

The theoretical basis of the articulatory suppression method is largely anecdotal in nature. Huey's (1908) use of the term "inner speech" with regard to phonological encoding during reading could have given rise to the idea of using articulatory suppression as a means of interfering with phonological encoding. If phonological encoding is "inner speech", then it must in some way be linked with "outer speech" or oral language. Thus if a subject is made to speak words unrelated to the passage being read while simultaneously reading silently for meaning, the "inner speech" processes must be interrupted. Further support for the use of articulatory suppression to interfere with phonological encoding during reading was drawn from studies of subvocalization (e.g. Edfeldt, 1960; Hardyck & Petrínovich, 1970), which employed measurements of small movements of the lips and tongue. The logic behind inferences drawn from these studies is that if normal silent reading, which presumably involves the use of phonological encoding, is accompanied by covert movements of the articulatory organs, overt use of the organs in producing

speech aloud will interrupt phonological encoding processes. Both these theoretical concepts may be criticized because they assume that the phonological processes involved in oral speech production and the phonological processes involved in silent reading are identical.

This "leap" may not be supportable in the light of neuropsychological theory and research. Although there may be an expressive-receptive speech axis whereby the production and reception of linguistic information may be linked in terms of underlying similarities, it is apparent from the neuropsychological literature (e.g. Luria, 1973, 1979 - see section 3.2) that there are separate brain mechanisms governing the production and "giving out" of linguistic information. Such linguistic information may be received auditorily (as in the perception of oral speech) or visually (as in reading engaging only visual routes of lexical access, e.g. the reading of graphic symbols such as \$ or %, or Arabic numerals) or by means of a combination of auditory and visual information (in reading complex material silently for meaning). It is therefore unlikely that articulatory suppression (the "giving out" of linguistic material) would interfere with phonological encoding involved in silent reading (the reception of linguistic material).

The simplistic nature of articulatory suppression tasks is also open to criticism. As the articulatory tasks involve a low level of processing while most reading tasks involve higher levels of

processing due to their relatively more complex nature, the likelihood of interference affecting comprehension is reduced. (The likelihood of "overload" of the mechanisms involved in the performance of the two tasks is minimized by the fact that the tasks require different levels of processing - only the simultaneous execution of tasks requiring a similar level of processing could lead to a performance decrement due to interference or information overload). Furthermore, the simple repetitive nature of most articulatory suppression tasks could result in the tasks becoming "automatic" (cf. LaBerge & Samuels, 1974) and hence not involving processes qualitatively similar enough to the process of phonological encoding in reading to result in the interruption of phonological encoding.

Another criticism which may be levelled at those studies that have reported an interference effect due to articulatory suppression is that such studies do not exclude the possibility that the interference observed may be due to divided attention (see Chapter 4). In one study where this has been regarded as a possibility (viz. Baddeley, Eldridge & Lewis, 1981), the "control" task was insufficiently similar to the articulatory suppression task to warrant generalization of the results of the experiment.

These objections to the use of the articulatory suppression task support Coltheart's (1980) argument that:

"studying the effect of concurrent articulation upon reading cannot at present tell us anything about the role or roles of

phonological encoding during reading"
(Coltheart, 1980, p.217).

Thus it is apparent that if the process of phonological encoding during reading is to be studied by the successful interruption of the process, a form of interference more closely related to the reading process is necessary. Hochberg and Brooks (1976) and Massaro (1979) have drawn parallels between speech perception and reading. This link between processing of information received by ear and that received by eye will now be discussed.

3.2 The link between taking in of information by ear (listening) and taking in of information by eye (reading)

Luria (1979) has observed that:

"behavioural processes that seem to have nothing in common may actually be related through dependence on a particular brain factor"
(p.78).

While spoken language and reading are superficially quite different activities, there is an awareness in recent research literature of the possible existence of common mechanisms responsible for speech perception and for reading.

"Reading and listening can be viewed as independent but analogous processes, the goal of which is to derive the meaning of the message"
(Massaro, 1979, p.332).

"Both language reception systems, for visible and for spoken language, may largely rely on a common process that we know little about, but that is likely to be quite unspecific to modality"
(Frith, 1979, p.385).

"Depending as heavily as it does on the language skills and on directed visual

search, reading text, as a perceptuomotor activity, has certain characteristics in common with listening to speech ..."
(Hochberg & Brooks, 1976, p.242).

Hence the possibility exists that there is a single brain mechanism responsible for reception of speech, whether the incoming information is visual or auditory. There is tenuous evidence that the same anatomical structures may be involved at some stage in the processing of both visual and auditory incoming information:

"There is evidence from electrophysiological work that activity in one sensory pathway may influence activity in another, and it may be that these interactions play some role in the interactions observed in the psychological studies"
(Horn, 1965, p.199).

However it appears to be of more value to the present investigation of the reading process to examine the functional similarity between taking in of information by ear and by eye and to identify the degree of "functional space" (Kinsbourne, 1982; Kinsbourne & Hicks, 1978(a)(b)) occupied by these processes, rather than to adopt a strict localizationalist viewpoint and to search for a common anatomical mechanism underlying both processes. This viewpoint is in accordance with Luria's (1973, 1979) conceptualization of the functioning of the human brain.

According to Luria (1973, 1979), functional brain mechanisms may be classified into three "blocks" or "units", namely Units 1, 2 and 3, which work together as a system.

Unit 1 consists of those mechanisms responsible for the control

of consciousness and the maintenance of cortical tone which provides the necessary stable basis for the organization of all higher cognitive functions, including reading. This unit comprises the brain stem, reticular formation, limbic system and the medial surfaces of the cerebral hemispheres.

Unit 2 controls the analysis, coding and storage of optic, acoustic, cutaneous and kinesthetic stimuli. Each area of Unit 2 responsible for the processing of the different types of sensory information consists of a hierarchical arrangement of primary, secondary and tertiary cortex. Primary cortex mediates sensory awareness of the physical environment. It is highly modality-specific, allowing for the intramodal analysis, sorting and recording of incoming sensory information in terms of its gross physical features (e.g. physical intensity, hue). Secondary cortex synthesizes, organizes and codes the information processed by the primary cortex. The tertiary cortex is the least modality-specific region of Unit 2, and is responsible for the intermodal synthesis of information from the secondary cortices of Unit 2. This intermodal processing allows for more abstract representation and synthesis of information.

Unit 3, comprising the frontal lobes, governs the formation of intentions and programs for behaviour. It can thus be regarded as the executive centre of the brain concerned with the output of information.

While no reading can take place without the concerted intact

functioning of Units 1, 2 and 3, the functioning of the unit directly responsible for the analysis, synthesis and storage of incoming sensory information, namely Unit 2, is of central importance to the present study. More specifically, it has been assumed that skilled reading engages non-modality-specific tertiary cortex (Luria, 1973; Geschwind, 1965, 1979). That is, reading involves the processing and association of input from both visual secondary cortex and auditory secondary cortex (in the form of phonological encoding) by tertiary cortex in order to arrive at abstract lexical-semantic "meaning".

According to the concept of limited cerebral functional space (Kinsbourne, 1978; Kinsbourne & Hicks, 1978(a)(b)), or limited processing capacity (Shwartz, 1976), it is apparent that there is a limit to the amount of information that can be processed by each cortical area of Unit 2 at one time. Therefore two processes simultaneously involving the same cerebral functional space will interfere with one another:

"The existence of limited capacity in a given stage of information processing is demonstrated by interference between two or more simultaneous inputs which occur wholly within that stage" (Shwartz, 1976, p.767).

Simultaneous processes occupying different functional cerebral fields could proceed optimally without interference between them. Tasks of differing complexity (e.g. the processing of white noise vs. the processing of semantically and syntactically complex verbal input) are assumed to engage different cerebral fields and there should be no interference between them.

There is also much evidence in the literature that the two brain hemispheres govern different processing strategies. In most right-handed and many left-handed people, the left hemisphere is responsible for verbal, sequential processing, while the processing strategies governed by the right hemisphere are largely spatial and wholistic in nature. Thus if a subject is required to process incoming information of a similar complexity and nature (e.g. only verbal or only non-verbal) from two sources (e.g. the concurrent performance of two similar tasks in one sensory modality or the performance of two tasks both requiring the concerted working of two or more sensory modalities, as in the case of two tasks both requiring tertiary cortical processing), information overload with its consequent decrement in task performance will result. However, if the tasks to be performed are different in nature (e.g. one verbal, one non-verbal), in complexity, or in both nature and complexity, the likelihood of inter-task interference and performance decrements is reduced.

To summarize, phonological encoding during reading has previously been investigated by the use of groups of subjects whose use of phonological encoding in reading is impaired or curtailed, or by the use of reading tasks designed specifically to tap phonological encoding processes. In much of the relevant research, articulatory suppression tasks have been used to interrupt phonological encoding. Such research was reviewed in Section 3.1. The contradictory and inconclusive results of many relevant studies were noted and explained in terms of the

inadequacy of the articulatory suppression technique as a means of "blocking" or interfering with phonological encoding during reading. Articulatory suppression was shown to be inadequate on two counts, viz.: the faulty theoretical logic underlying its use, and the simplistic nature of the tasks used. In Section 3.2, the link between processing of auditory information and processing of visual information was discussed in terms of the functional similarity between the two processes. Luria's (1973, 1979) model of the "working brain" was outlined and related to the present research. It was argued that there is a limit to the amount of information that can be processed by each cortical area of Unit 2 at one time. The nature and complexity of the tasks to be performed were shown to contribute to whether or not information overload would occur.

3.3 Auditory interference and reading

One conclusion which emerges from the preceding discussion, is that auditory input may interfere with phonological encoding processes during reading where articulatory suppression interference may not. This possibility was also inherent in Vallar and Baddeley's (1982) suggestion that in the investigation of short-term memory (and presumably thus also in reading): "it would clearly be useful to have an auditory equivalent to articulatory suppression" (p.59). Because of the differences in processing strategies employed by the different brain hemispheres, it is of importance to distinguish between the

interfering effects on reading of nonverbal (e.g. music or white noise) as opposed to verbal auditory input.

Previous research has indicated that nonverbal auditory input does not interfere to an appreciable extent with verbal tasks. Franklin (1976) found no appreciable decrement in reading performance when teenage readers were subjected to rock music at different levels of intensity while reading narrative stories.

Although the affect of white noise on reading tasks has not been assessed, Hintzman (1965) and Murray (1965) have investigated the effect of white noise interference on short-term memory tasks. Colle (1978) observed that white noise did not impair visual serial recall while speech noise did. As no interference effect was found in any of these studies, and as short term memory (at least) is involved in reading, it seems unlikely that white noise should have an effect on reading comprehension.

Verbal auditory interference has been employed in previous research (e.g. Colle, 1980; Colle & Welsh, 1976; Mowbray, 1953; Salamé & Baddeley, 1982). However it has either been used in the investigation of tasks not specifically designed to tap phonological encoding during silent reading for meaning (e.g. short-term memory tasks), or it has been limited to elementary levels of verbal interference, and to experimental situations in which the primary reading tasks used did not observe a prelexical/ postlexical phonological encoding distinction. The relevant findings will now be discussed.

Horn (1965) cited a study by Mowbray (1953) in which a prose passage was relayed to subjects auditorily while they read a second passage which was presented visually:

"The performance on a visually presented passage, when this was presented alone, was always better than the performance on the same passage when another passage was delivered at the same time over a loudspeaker" (Horn, 1965, p.160-1).

However, one must be cautious in applying these results to the topic under consideration in this thesis, in that Mowbray's study did not aim at investigating phonological encoding during reading, but at memory and attention. A number of methodological flaws further marred the study:

- i) subjects were instructed to attend to both the passage presented visually and that presented aurally, and had to answer questions on both passages,
- ii) the visual passages were presented one line at a time (an artificial reading situation),
- iii) accuracy and latency data were not analysed separately.

Colle and Walsh (1976) investigated the effect of auditory interference (a foreign language) on the serial recall of phonologically similar and phonologically different lists of letters. They found a decrement in performance on the phonologically different lists in the presence of noise. This

decrement in performance was not observed in the case of phonologically similar lists. These results were used to support a model of a primary auditory sensory memory. However, the results cannot be generalized to more complex reading tasks involving a larger memory load, and requiring semantic and other forms of processing. It may be that the memory task used in Colle and Welsh's study focused on a low-level physical analysis and storage of information which would be disrupted by any incoming auditory information, verbal or nonverbal.

Baddeley, Eldridge and Lewis (1981) used an auditory interference condition consisting of the repetition of fifteen one-syllable CVC words on an audiotape relayed to the subject while he performed a reading task which required the identification of permuted words in a number of narrative reading selections. They obtained no significant decrement in performance when auditory interference was present as compared to when it was absent.

From the results of the above-mentioned studies it can be inferred that auditory interference will have a differential effect on reading performance, depending on the complexity and level of processing required by both the reading task and the auditory interference. The extent to which the consequent division of attention and processing space occurs between the reading task and the interference will also influence task performance.

In summary, there is a possibility that auditory input will

interfere with phonological encoding processes during reading where articulatory suppression does not. A distinction was made in this section between the interference effects on reading of nonverbal auditory input (music or white noise) as opposed to verbal auditory input. Previous research has revealed that music has no effect on reading comprehension (Franklin, 1976). In the light of the results of studies investigating the effect of white noise on short-term memory tasks (Hintzman, 1965; Murray, 1965), it appears that white noise will have no effect on the performance of reading tasks. Verbal auditory input employed in previous research has either been used in the investigation of tasks not specifically designed to tap phonological encoding during reading or it has been limited to elementary levels of linguistic interference where the primary reading tasks used did not observe a prelexical/postlexical phonological encoding distinction. Relevant studies employing verbal auditory interference (Baddeley, 1982; Baddeley et al., 1981; Colle & Welsh, 1976; Mowbray, 1953) were discussed.

3.4 General summary and implications

In the past, many researchers have attempted to disrupt the hypothetical phonological encoding which takes place during reading, by means of interference tasks, usually involving articulatory suppression. According to this method the subject performs a reading task while concurrently repeating a word (e.g. "double" or "bla") or a series of numbers out loud, or

"shadowing" a string of digits or sounds. Results of studies employing articulatory suppression methods have been inconclusive and contradictory. A number of these studies were discussed in Section 3.1. The use of the articulatory suppression technique to disrupt phonological encoding during reading was shown to be inadequate. This was accounted for in terms of a possible misunderstanding of neuropsychological processes and the simplistic nature of the tasks used. Studies which have reported an interference effect due to articulatory suppression were also criticized because they did not exclude the possibility that the interference observed was due not to the articulatory suppression but to divided attention. In the light of these criticisms an alternate method of interrupting phonological encoding during reading (namely auditory interference) was employed in the present research.

In Section 3.2 the functional similarity between auditory reception of information and visual reception of information was discussed in the context of Luria's (1973, 1979) model of the "working brain". It has been assumed that skilled reading engages the tertiary cortex of Unit 2. It is irrelevant in terms of this model whether information reaches the tertiary cortical level by a visual channel or by an auditory channel, because tertiary cortical processes are non-modality-specific. There is a limit to the amount of information that can be processed by each cortical area of Unit 2 at one time. An information overload could result in: a) a decrement in performance of the primary reading task in terms of either latency or accuracy or

both; b) the "holding" of information in an alternate store, perhaps at a lower level of processing. Information overload will occur when two tasks of a similar nature are to be performed simultaneously and the combined processing requires more "space" than a processing "threshold" permits.

Thus the possibility exists that auditory input will interfere with phonological encoding processes during reading where articulatory suppression does not. A distinction was made between the interference effects on reading of nonverbal (music or white noise) as opposed to verbal auditory input. Previous studies employing different types of auditory input were discussed. The present research investigated the effect of both nonverbal (music, white noise) auditory interference and verbal auditory input at varying levels of complexity on reading performance on a number of reading tasks of varying complexity. An articulatory suppression task was also used in an attempt to replicate previous research findings. Before turning to a discussion of the experiments which constituted the body of this research, it is necessary to discuss the role played by attention in reading.

CHAPTER FOUR: ATTENTION AND READING

"Increasingly theoretical speculation about the nature of the reading process has led to the conclusion that selective attention must play a central role (in reading)"
(Willows, 1974, p.408).

Despite Willow's claim, few researchers, using the "interference" paradigm in studying reading processes, have directly addressed the question of the relationship between selective or divided attention and reading. In particular, the precise role of attention and selective or divided attention in reading has not been clearly defined in many studies which have attempted to interrupt phonological encoding by means of articulatory suppression tasks. In some studies (e.g. Baddeley, Eldridge & Lewis, 1981) selective attention has been regarded as a confounding factor but has then been discounted.

With regard to the present research, it is important to determine to what extent an individual who is performing two tasks simultaneously, regarding one (e.g. a reading task) as primary and the other (e.g. listening to auditory input) as secondary, can attend selectively to some stimuli while "ignoring" or "blocking out" others. The secondary task may not necessarily distract one's attention from the primary task, depending on the nature of the tasks and the type of processing they require.

Models of attention and related research relevant to the present study will be discussed in this Chapter.

4.1 Models of attention

Klatzky (1980) has summarized various early cognitive models of attention. The models she has outlined do not have direct relevance to the present research. However it is necessary to consider the concepts put forward in these models before the more relevant hierarchical models of attention (Section 4.2) and the reading model proposed in the present research may be understood. The early models of attention that are most relevant (viz. the models of Broadbent, Treisman, Norman, and Craik & Lockhart) will therefore be reviewed briefly. Kinsbourne's neuropsychological model of attention (Kinsbourne, 1970, 1982; Kinsbourne & Hicks, 1978) will also be discussed in this section.

4.1.a Broadbent's "filter" model of attention

Broadbent has drawn on concepts in the field of information processing, in particular, the idea that information flows along "channels", in formulating his model. As applied to human information processing, these "channels" may be visual, auditory, kinesthetic/cutaneous, etc. According to Broadbent (1958):

"selective attention acts like a filter, blocking out some channels and letting only one through. The blocking-out process is made possible by an analysis of the incoming messages on all channels for their physical characteristics. A particular message can then be selected and attended to on a physical basis" (Klatzky, 1980, p.71).

This model appears to be supported by the results of dichotic listening experiments which show that physical features of unattended messages are recognized (for example, is the message human speech or non-human sound? Is the voice heard male or female?). The recognition of features which would indicate higher levels of processing of irrelevant messages is absent (e.g. subjects cannot say anything about the content of the irrelevant message or recall any of its words and cannot identify the language in which the message was spoken or whether the language changed in the course of the experiment, or whether the message consisted of actual speech or nonsense).

4.1.b Treisman's model

Treisman (1960) showed that more than mere physical features are selectively attended to, in that a subject can follow a message which is switched from ear to ear in a dichotic listening task. In 1964 she extended Broadbent's model by postulating that all incoming stimuli are subjected to a number of "tests", the initial tests analyzing stimuli on a gross physical level, with subsequent, more refined, tests analyzing input in terms of content. When these tests have been completed, attention is directed to one or other of the information channels, depending on that channel's involvement in the task being performed, or the subjective "centrality" of the task to the subject. This model accords well with hierarchical models of selective attention (e.g. Luria, 1973; Martin, 1980), which propose that different

mechanisms operate at different stages in the perceptual process (e.g. initial registration of stimuli takes place on a sensory level. Feature analysis and synthesis of the information then occur at a different level. At yet another stage content analysis and relating of the incoming information to information already held in the person's cognitive system takes place). However the specific mechanisms involved in determining which stimuli will be attended to in preference to others remain largely unexplored in Treisman's (1964) model.

Treisman and her colleagues (Treisman & Gelade, 1980; Treisman, Sykes & Gelade, 1977) have applied her original model of attention to tasks which require the simultaneous processing of two or more stimuli. They proposed that;

"when more than one ... stimulus is presented, subjects avoid perceiving illusory conjunctions composed of wrongly paired attribute values by focusing attention on one location at a time and thus processing the stimuli serially" (Treisman, et al., 1977, p.333).

However, parallel processing of stimuli may occur when:

- 1) the stimuli vary along one attribute only
- 2) the stimuli are multidimensional but the correct conjunctions are irrelevant
- 3) the stimuli are multidimensional but share no attributes which could be wrongly recombined" (Treisman, et al., 1977, p.333).

Thus it is possible for different stimuli (e.g. visual and auditory) to be processed simultaneously. However the experimental tasks used in verifying this model (for example, distinguishing between simultaneously presented geometric shapes differing in terms of only one attribute, e.g. colour, size),

have been largely nonverbal and simplistic in nature. Thus the applicability of this model to the complex reading task situation employed in the present research is limited, and other models of attention must be examined.

4.1.1.c. Norman's model

A model which favours a further "pre-attentive" stimulus processing approach, to use Neisser's (1967) term, is that of Norman (1969) who extended Treisman's model by proposing that stimuli on all channels impinging on the processing system are analysed sufficiently to activate representation in long term memory. Hereafter selective attention operates. This corresponds to the full recognition of patterns (in our case, the accessing of meaning of printed words) on just one channel (the most highly activated one). Patterns on competing channels do not receive attention and are eliminated from further processing; therefore recognizing a pattern corresponds to attending to it.

Norman's (1969) model points to a dichotomy between activation and attention. "Activation" corresponds to directed activation or subjective focusing on particular features of stimuli. The link between attention and activation remains unclear from Norman's model (e.g. can a state of "activation" exist without "attention"?). However other researchers (notably Hellige, Cox & Litvac, 1979; Gaffen, Bradshaw & Nettleton, 1973; Kinsbourne, 1970) have attempted to explain attentional processes in terms of

selective activation and "biasing" of the different cerebral hemispheres by the nature of the experimental tasks employed.

4.1.d Kinsbourne's model

Kinsbourne's model of attention (Kinsbourne, 1970; Kinsbourne & Hicks, 1978) was originally formulated to explain the role of attention in the performance of motor tasks. According to the model, lateral asymmetries in attention arise when preponderant activation of one cerebral hemisphere biases attention to the contralateral side of the body. Such unbalanced cerebral activation is a function of the nature of the subject's task and expectancy. For example, when the subject is required to perform a tapping task with his right hand, attention will be biased by the left hemisphere to the right side of the body.

Hellige, Cox and Litvac (1979), in testing Kinsbourne's model and extending it to examine selective attention in tasks involving right hemisphere functions, concluded that:

"neither directness-of-pathway (Kimura, 1966), nor attention gradient laterality models can explain the entire pattern of results from the present experiments. Rather, the results suggest that the left hemisphere functions as a typical limited-capacity information processing system that can be influenced somewhat separately from the right-hemisphere system"

(Hellige, et al., 1979, p.251).

When Kinsbourne's model is applied to the performance of a

reading task (a verbal task requiring left hemisphere processing), it is apparent that attention will be biased to the task by the left hemisphere. In terms of Hellige et al's statement (quoted above), the left hemisphere operates as a system separate from the right hemisphere. Thus a task requiring right hemisphere processing may be performed simultaneously with a reading task with little decrement in performance due to attention capacity overload. However, Hellige et al. have also highlighted the importance of the nature of the tasks to be performed in determining biasing of attention, and in particular the level of processing the task requires. Craik and Lockheart's (1972) model of memory, to which attention and the concept of "levels of processing" are of central importance, will now be discussed.

4.1.e Craik and Lockheart's "levels of processing" model

In 1972 Craik and Lockheart proposed their "levels of processing" model. The model, as originally applied to memory research, is stated as follows:

"Perception involves the rapid analysis of stimuli at a number of levels or stages... A series or hierarchy of processing stages is often referred to as 'depth of processing' where greater 'depth' implies a greater degree of semantic or cognitive analysis... Analysis proceeds through a series of sensory stages to levels associated with matching or pattern recognition and finally to semantic-associative stages of stimulus enrichment... Retention is a function of depth, and various factors, such as the amount of attention devoted to a stimulus... will determine the

Author Christowitz J

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

PUBLISHER:

University of the Witwatersrand, Johannesburg

©2013

LEGAL NOTICES:

Copyright Notice: All materials on the University of the Witwatersrand, Johannesburg Library website are protected by South African copyright law and may not be distributed, transmitted, displayed, or otherwise published in any format, without the prior written permission of the copyright owner.

Disclaimer and Terms of Use: Provided that you maintain all copyright and other notices contained therein, you may download material (one machine readable copy and one print copy per page) for your personal and/or educational non-commercial use only.

The University of the Witwatersrand, Johannesburg, is not responsible for any errors or omissions and excludes any and all liability for any errors in or omissions from the information on the Library website.