The Acquisition of New Reading Vocabulary
in Normal and Poor Readers

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Abstract

The ability to learn new reading vocabulary was assessed in normal and poor readers. Ten normal readers and ten children reading two or more years below their grade level were taught two lists of eight new reading words on a micro-computer. One list consisted of phonetically-regular words while the other list included phonetically-irregular words. The children were all approximately nine years of age and in the normal range on the I.P.A.T. Culture Fair Test of ‘g’. After being introduced to the to-be-learned words, each subject practised identifying his/her words for 10 sessions of three trials each, over a period of five days. Visual distractors were included in the practice set to assess word-identification accuracy, recognition-memory accuracy as well as word-identification speed. The results suggested that both normal and poor readers engage in visual-feature learning and lexical-association learning when acquiring new reading vocabulary. However, poor readers appear to engage in less visual-feature learning per trial than normal readers. As a result, they may establish fewer lexical-visual associations per trial. The results suggested that this may be the cause of their lower word-identification accuracy and speed. In addition, the learning curves for both groups appeared to be a function of the "power law of practice" (Newell and Rosenbloom, 1981). There was also some evidence suggesting that poor readers may sample easier parts of the new reading words than normal readers and thus learn at a slightly faster rate even though their vocalization latencies were significantly longer. There was no effect according to the phonetic regularity of a word for either group.
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CHAPTER ONE

The Acquisition of New Reading Vocabulary
in Normal and Poor Readers

One defining characteristic of a competent reader is a reading rate that is at least average for the comparison population or age group. Currently, measures used to assess reading rate are largely grade and age-level achievement measures of reading comprehension, speed and accuracy. We know the disabled reader has a slower reading rate, resulting from a slower speed of decoding words and slower lexical retrieval (Perfetti, 1985). We do not know how performance changes or improves as a result of learning a word by reading it several times.

It is assumed that recognizing printed words is important in learning to read although there is disagreement about the best way to develop word-recognition skill. One recommendation is that the learner practice reading new words to improve decoding accuracy and speed (Smith, 1971). This approach assumes that experience reading a word, as opposed to direct instruction in an area like phonics, underlies reading ability.

Perfetti (1985) has concluded that tasks involving the production of a word name when the presentation of the visual stimulus is experimentally controlled leads to consistently large and reliable ability differences. This conclusion was based on a series of experiments designed to tap decoding-speed ability differences at the word and nonword level. However, these measures have been limited to a few practice trials and have not generally gone beyond the initial stages of word learning. Thus, there appears to be a
need to investigate word-learning performance over a larger number of trials and to examine the development of word-reading accuracy, recognition, and speed in relation to one another.

Does the slow reading rate of a disabled reader result from a slower rate of learning new words? Perhaps reading disability stems from a problem learning complex or irregular-orthographic rule systems in general (Barron, 1981). Difficulty in mastering irregular systems of rules in symbol-sound correspondence could hamper the development of rapid decoding. Alternatively, a slow decoding rate may result from a failure to learn reading vocabulary words to the point of recognizing a word quickly and effortlessly before new words are introduced (LaBerge and Samuels, 1974).

Existing models of word learning are limited in their explanation of how speed and accuracy of word learning interact. Perfetti's (1985) verbal-efficiency theory stresses the limited resource-processing system in which reading processes take place. Coding processes, the rules mapping letters to phonemes, are needed to work fluently and with little effort so that the reader can use higher-level comprehension processes when reading text and build meaning representations of the text in memory. Low-ability readers may be hampered by slow and inefficient coding.

Ehri and Wilce (1983) have investigated word decoding in a three-phase learning model. The initial phase addresses a type of paired-associate learning in which the sounds of a word are mapped onto individual letters or clusters of letters which, when recognized, retrieve the words name. Accuracy is the variable of primary interest in phase one but their model does not clearly distinguish between the encoding processes used in learning a word and the decoding processes required to read a word. The
experiment reported here seeks to further specify the relationship and/or interaction of word-naming accuracy and response speed in this first phase.

A greater amount of research on the components of word learning seems to exist in the verbal-learning literature. Research has distinguished between measuring word learning in terms of response time, accuracy or recall memory as well as recognition memory. Wagner (1985) has investigated these processes and relationships in a three-part model of visual-word learning which consists of associative learning, visual-discrimination learning and trace strengthening. He assumes that visual-word learning requires both within-code elaboration learning and between-code association learning. Within-code learning refers to establishing visual, auditory, and semantic features of a word while between-code learning refers to the establishment of auditory-visual, semantic-visual, and auditory-semantic associations.

Wagner regards associative learning and visual-discrimination learning as independent processes for poor readers which often differentiate normal from poor readers (Wagner, 1983; Bitondo, Putzman and Wagner, 1985). Poor readers in these experiments tended to concentrate on within-code visual-feature learning at the expense of between-code associative learning. This experiment seeks to clarify whether normal and poor readers can be further differentiated by the measurement of the strength of visual-lexical connections established through practice in word identification as indexed through subject vocalization latency.

The purpose of this study then was to assess visual-word learning in normal and poor readers. Specifically, it entailed measuring and seeing what the normal learning curves looked like for normal and poor readers identifying new words presented on the computer screen over repeated
trials. The main dependent variable of interest was vocalization-response latency although reading and recognition-memory accuracy were also measured. In this study, the poor reader, the dyslexic or the reader with a specific learning disability referred to a child who was normal or above normal in nonverbal IQ, two years behind in reading achievement, and with a reading disability that was not caused primarily by social, economic, motivational, or emotional factors (Rabinovitch, 1968).

A comparison of normal readers' and disabled readers' performance was made on phonetically-irregular and phonetically-regular words. Words composed of simple, regular, and predictable letter-sound (grapheme-phoneme) correspondences are termed regular-phonics. Words that include one or more infrequent, irregular, or unpredictable letter-sound correspondences are termed irregular-phonics. These are words that are commonly introduced as "sight words" because they cannot be either decoded or spelled correctly on basic phonics principles. Decoding or word identification within this framework refers to matching the visual information encoded in a stimulus word to the visual information stored in long-term memory and retrieving the auditory components of a logogen on the basis of their associations with the visual information in long-term memory.

Some models of word identification emphasize the use of letter-to-sound rules to retrieve a word's meaning where other models stress a direct access through the visual features of a word to its name or meaning. In both cases, knowledge stored in long-term memory constrains a reader's responses in identifying or decoding a word (Stanovich, 1980). The literature suggests normal readers are more flexible and can use either
method of word retrieval whereas poor readers tend to rely more heavily on one approach (Mitterer, 1984; Boder, 1971).

In general, it was hypothesized that disabled readers would learn new reading words at a slower rate than normal readers as measured by their longer vocalization latencies to words presented on a computer screen across trials. Disabled readers were expected to be poorer than normal readers at word-naming accuracy and recognition memory overall. The index of visual-feature learning was the word-recognition score; the index of the number of lexical-visual associations formed was the word-naming score; the strength of the visual-lexical associations was indexed by the word-naming speed.

Three specific predictions were made in regard to the visual-word learning performance of the poor reader:

(a) The poor reader may be both less accurate and slower in naming speed than the normal reader but perform just as well in visual recognition of the word.

(b) The poor reader may maintain naming accuracy and word recognition at the same level as the normal reader but be slower in naming speed.

(c) The poor reader may be less accurate in word naming, less accurate in visual-recognition memory, and be slower in naming speed.

It was also hypothesized that the differences between groups would be greater for phonetically-regular words than sight words. However, both normal and poor readers were expected to be faster and more accurate in reading phonetically-regular words than reading sight words. Implied, is the supposition that although poor readers may have less complete and weaker auditory-visual associations than the normal reader, they are not
completely reliant on sight word semantic-visual or name-visual associations.
Are poor readers slow word decoders?

There is agreement among many current reading models that words must be rapidly processed for fluent reading to occur (Perfetti, 1985; Stanovich, 1980; Smith, 1978; LaBerge and Samuels, 1974). Reading must be rapid so that several words can be integrated into a meaningful set of propositions in short-term memory. Slow reading may overload short-term memory and leave less processing capacity for the higher-order comprehension processes. LaBerge and Samuels (1974) and Perfetti and Lesgold (1977) have argued that comprehension breakdown occurs if words are not decoded in short-term memory at a fast automatic rate.

Mastery of the decoding process requires the ability to analyze the features of letters, decode letters to sounds, and recognize higher-order spelling-pattern units (Gibson and Levin, 1975). When mastered to the level of automaticity (LaBerge and Samuels, 1974), the reader is able to anticipate and accurately guess a word's identity based on the rapid perception of a syllable, letter group, or general word or syllable configuration. Once decoding is complete, the reader must quickly and accurately gain access to the word's meaning. Lexical access is possible when the meaning for the word is already within long-term memory.

According to LaBerge and Samuels' model, it is assumed that the amount of attention required for decoding is modifiable by the amount of over-learning or practice given to the process. Automatic word recognition permits the reader to devote full attention to the "higher-level" syntactic and semantic processes involved in comprehension. Lesgold et al. (1981)
also report from their longitudinal study that children, who were repeatedly tested on their word recognition speed, improved in reading comprehension.

Automatization was demonstrated in LaBerge and Samuels' (1974) experiment of letter recognition. Participants thought their main task was a successive letter-matching procedure and they were instructed to respond "same" or "different" after having viewed a single letter projected on the screen. The experimenters unexpectedly presented pairs of identical letters. Subjects did not take longer to respond "same" to an unexpected letter pair following a single letter cue than to an expected single letter. The assumption was that the unexpected stimuli allowed a measurement of perception when attention was directed elsewhere. The finding suggests that if information is so well learned that it is automatic, it does not require attention and can be perceived readily. This implies that words or letters which are only partially mastered will require attention. It also underlies the problem facing the new reader who is faced with a divided attention problem. The beginning reader must learn the connection between the visual symbols on the page and the name of the symbol and at the same time must pay attention to the meaning of what he or she is reading.

There is a strong relationship between word-recognition speed and reading ability, particularly in the early grades. Fluency in reading a paragraph can be predicted with high accuracy from the speed with which a student names isolated words. Shankweiler and Liberman (1972) observed correlations in the range of .5 to .8 when word-naming speed and accuracy were compared with paragraph-reading fluency in second, third, and fourth-grade readers.

Poor readers appear to be slow decoders. Perfetti has conducted a series of studies based on the bottom-up model of word learning. His
premise is that most poor readers are slow decoders and it is at the word-decoding level that difficulties arise. His experiments have pinpointed some of the difficulties at the word level.

Using vocalization latency as the main dependent measure, Perfetti and Hogaboam (1975) found that poor readers named even high-frequency words about 150 msecs. slower than good readers. Grade-three skilled readers averaged 1.303 secs. and less-skilled readers averaged 2.382 secs. to a list of ten known words. The finding stresses the difficulty the poor reader may encounter in maintaining comprehension, as information cannot be rapidly processed in short-term memory, even with familiar reading vocabulary. Differences between the two groups in decoding latency increased as a function of word difficulty, including number of syllables, word length, and word frequency (Perfetti, Finger and Hogaboam, 1978; Hogaboam and Perfetti, 1978; Perfetti and Hogaboam, 1975). The difference was greater for two-syllable words and especially for three-syllable words even when frequency was controlled.

In earlier experiments, Perfetti and Goldman (1976) found that good and poor readers may not differ with respect to auditory short-term memory capacity per se but that normal readers may be better in the verbatim recall of orally presented text. This suggests that poor readers may have difficulty keeping track of incoming propositions or concepts as attentional capacity must be allocated to the auditory decoding of individual words (Case, 1974). Not surprisingly, poor readers appear to use context to assist in identifying single words to a greater extent than normal readers. Vocalization latencies for both groups were shorter within story contexts whether heard or read with latencies more reduced for the poor reader group (Perfetti and Goldman, 1976).
What are the causes of slow word identification in poor readers?

A number of causes or sources of slow word-identification speed have been identified in poor readers. Differences in decoding latency may be due to a slower process of general name retrieval in poor readers. Perfetti, Finger, and Hogaboam (1978) had third-grade subjects name colours, digits, pictures, and words. Only word stimuli produced significant differences between groups which suggests that retrieval speed is not the major source of decoding-speed difference. This finding was restricted to reader abilities found in a normal classroom and single-item responding.

Other studies using subjects who were more impaired in reading ability than in Perfetti's studies, two years below grade level, have found conflicting results. Denckla and Rudel (1976) and Spring and Capps (1974) did find differences in more general name retrieval, as dyslexic subjects named digits, colours, and pictures of common objects more slowly than average readers. However, in the Perfetti et al. (1978) studies, what is measured is the time to name an individually presented item, whereas the Denckla and Rudel and Spring and Capps' studies measure the time to name items presented on a chart. It is conceivable that the chart procedure may also measure sequencing and resistance to interference as well as naming time (Perfetti, 1985). This could mean that the naming times were inflated with these groups of readers.

The time to name a word includes both decoding time and time for response preparation and execution. Manis (1985) questioned whether differences in naming latency between groups of fifth and sixth-grade normal and disabled readers could be due to poor readers' slower response processes. Even after groups were given a delay to prepare their response,
poor readers were about 75 msecs. slower in naming speed. The major portion of the variance in reading ability occurred in the decoding component. Disabled readers were 300 msecs. slower in naming known words and 500 msecs. slower in naming low-complexity regular words after three sessions of practice. This procedure utilized vocalization latency to a word presented individually from a list of eight words with each list presented three times. However, the study did not separate accuracy, recognition, and word-naming speed.

It has also been acknowledged that poor readers require more time than good readers to process visual stimuli. This suggests that poor readers may be slow in identifying the letters or orthographic features of a word (Jackson and McClelland, 1979). Stanley and Hall (1973a) found that dyslexic children needed almost twice as much time as normal readers to correctly identify component parts of a figure. Poor readers also processed fewer digits than normal readers when a series of digits were presented visually at brief exposures (Stanley and Hall, 1973b). Results suggest that when ordered items are processed slowly, the reader will have difficulty remembering the relative order of the items and in detecting differences between various orderings of letters.

Good readers also know more word meanings than do poor readers, that is, there are more semantic entries in memory with more semantic detail (Perfetti, 1985). Among low-ability readers in third and fifth-grade, the speed of decoding was faster if the subjects knew the word meanings whereas the high-reading group was unaffected. This suggests that word meaning should be a controlled factor when there is an attempt to compare word-naming speed in good and poor readers.
Naming speed can be influenced by words from an open or closed set. A closed set is a restricted set, as in the names of the four seasons or the twelve months. An item from an open set is less predictable. It could include all proper names. High-ability readers appear to be faster in both conditions and especially faster for an open set that has a large number of items (Perfetti et al., 1978). This result suggests that poor readers may be hampered by the unpredictability of an item which has little activation prior to its presentation. However, if the target set in a word-learning condition is not large enough, the subject could store the items in memory as a list structure and then compare the test stimulus with each item on the list (Atkinson and Juola, 1974).

Slow word identification in poor readers may also stem from deficits in knowledge and retrieval of auditory-visual associations. There are a number of studies which have compared normal and poor readers' word-naming ability as a function of orthographic regularity. Ellis (1980) concludes dyslexic children are impaired in lexical access and lexical retrieval of pronunciation as well as in retrieval of phonology when applying grapheme to phoneme rules. Dyslexic children (aged 10-14) were slower than control children at reading common and frequent words which were well within the children's reading vocabulary. Consistently, Snowling (1980) found dyslexic children were both slower and more error prone at reading orthographically-regular nonsense words than normal readers.

Word recognition means that the word is associated with a familiar concept represented in the reader's memory. The term, mental lexicon, is often used to refer to a structured storage space where information about words is represented (Barron, 1981). For each word there exists a location where various sources of information about the word (semantic, syntactic,
phonological, and visual-orthographic) are interconnected. When this location is activated, information about the word or its meaning, becomes available to consciousness.

A printed word has two access codes by which it can activate the mental lexicon. One is by phonological processing, and the other is based on the visual-orthographic features of the word. These features can be coded by the visual system into a form that matches the visual-orthographic representation of the word which is stored in the lexicon. A match between the coded visual-orthographic features of the stimulus and the stored visual-orthographic representation activates the meaning of the word.

Phonemic recoding refers to the process of a word seen, not heard, and the search through the internal lexicon in the "phonemic code". It involves assigning sound values to letters or letter clusters on the basis of orthographic rules. Rubenstein et al. (1971) provided evidence of recoding occurring prior to lexical access. When adults were asked to distinguish between words and nonwords, they found that it took longer to decide that nonwords which rhyme with words were in fact nonwords than nonwords which did not rhyme with words. The use of phonetic information seems to consume more time than a visual analysis in lexical-decision tasks.

The whole-word skill involves the memorization of a large set of associations between printed words and responses. Memory for these unique associations is most important rather than orthographic rules. The whole-word method relies on the reader's ability to experience the written word globally as a visual gestalt, whereas the phonics method relies on the reader's ability to analyze words into their phonic components. These two cognitive components of the reading process correspond to the gestalt-simultaneous processing and the analytic-sequential processing that are
mediated by the right and left brain hemispheres respectively (Kaufman, 1983).

Barron (1981) concludes that both the visual-orthographic and the phonological access processes can execute simultaneously. A deficiency in either process could cause poor word recognition. The reader may attempt lexical access along both routes, a "horse race" in a sense, as the route that results in lexical access is the "winner". This mediational model of recoding print to sound, predicts that in average readers, regular words should be accessed more quickly than exception words. The speech-recoding route could sometimes "win" in the case of regular words however irregular words only have one visual route to use.

Baron (1979) established that phonological coding is the predominant way regular words are accessed in normal readers. Ehri and Wilce (1983) also confirm that a great deal of phonological coding is used when children are learning to read but that this decreases as the student progresses through the early grades.

In Manis' (1985) study, normal and disabled readers pronounced regularly-spelled words more accurately and quickly than irregularly-spelled words although normal readers were more accurate in their pronunciation and faster overall. Normal readers were unaffected by low and high-complexity words. Naming accuracy and latency were more strongly related to both regularity and complexity for disabled readers. Disabled readers made more errors on irregular than on regular words as well as on high-complexity relative to low-complexity regular words. The author concludes disabled readers have difficulty learning to recognize words rapidly if they do not know some of the letter-sound correspondences in the word or the word contains irregular correspondences. He suggests that
disabled readers are able to use correspondence rules, providing they are familiar to the reader.

Lexical-decision tasks require subjects to determine if a letter string represents a word or nonword. These tasks measure accuracy and response time. Stanovich & Bauer (1978) presented subjects with lexical-decision tasks involving regularly and irregularly-spelled words. Irregular words required more time but only at longer response latencies (550 msecs.). When subjects had to decide within shorter time periods, (350 msecs.) the difference disappeared.

Mitterer (1984) cautions that disabled readers should not be treated as a homogeneous group. Whereas the good reader can use both recoding and whole-word skills when identifying words, the poor reader is less flexible and due to a deficit in either word-identification skill, will rely too heavily on either the recoding or the whole-word skill.

Bader (1971) has devised a classification scheme to describe the strengths and deficits in the gestalt and analytic functions of dyslexic children in characterizing reading-spelling patterns not found among good readers who are at or above grade level in both reading and spelling. These groups are the dysphonetic, the dyseidetic, and the mixed dysphonetic-dyseidetic. A fourth, normal reading-spelling pattern is exhibited not only by good readers and spellers but by poor readers whose reading disability is nonspecific.

Dysphonetics or the "auditorally impaired" appear to use a holistic-learning style in reading by the visual recognition of whole words as gestalts and in spelling by errors which are usually non-phonetic.

Dyseidetics or the "visually impaired" are not very good at whole-word learning as they use an analytic style to remember the sequential
order of elements of a word. Words are spelled the way they sound rather than the way they look, spelling "laf" for laugh, for example. This group is prone to making visual-discrimination errors because of inferred difficulties in visual perception and memory.

A third subgroup described by Boder is characterized by both visual and auditory deficits and is poor at both whole-word learning and word analysis. It is the dysphonetic group which is the largest. Administering Boder's procedure revealed that 63 percent of the children fell into the dysphonetic group, 9 percent into the dyseidetic group, and 22 percent into the combined group. This finding is consistent with studies indicating that deficits in the auditory channel or central auditory processing, auditory perception, discrimination and sequencing, sound-symbol integration and word analysis-synthesis are more frequently associated with reading disability than are visual-spatial perceptual deficiencies (Kaufman, 1983).

There is some problem with Boder's theory according to Vellutino (1979). Differential error patterns observed in the oral reading and spelling of poor readers can be explained by instructional and experiential deficiencies. The beginning reader may have been exposed to a reading program which stressed either a phonics approach or a sight-word approach to word identification.

Poor word learning or poor encoding strategies will lead to slow word-identification speed. Ehri and Wilce (1983) have defined three phases in the development of word-reading skill which helps explain why less-skilled readers may not be able to improve decoding speed even with extensive practice. The model discusses initial word-learning acquisition but is limited in its account of extended word learning. This model is based
on the theory of automatic information-processing proposed by LaBerge and Samuels (1974).

In the first phase of this model, unfamiliar words are identified by directing attention to individual letters and letter-sound correspondences. Unfamiliar words become familiar and are recognized accurately. In phase two, as a result of practice in reading, children become able to recognize words rapidly and automatically as wholes without attention and without deliberate processing of component letter-sound relations. In the third phase, the speed of processing continues to increase to a maximum as the spellings are stored in memory and integrated with their pronunciations and meanings. Visual images replace sound so the reader can recognize the word by matching the print to his stored visual representation. There is then a direct access to the word's memory location from the visually-encoded word or letter string at a maximum speed for the individual reader.

Ehri's theory of printed-word learning explains why practice may be ineffective for younger poor readers. Poor readers lack adequate knowledge of letter-sound relationships and have trouble retaining and integrating complete spellings of words with their pronunciation in memory. The stored spellings are partial and do not specify how all of the word is pronounced. When these words are read it then takes longer to locate the spellings and retrieve their pronunciations in memory. Practice will not be beneficial until there is more knowledge about how orthography maps onto speech. The beginning reader needs to acquire some familiarity of common letter-sound correspondences and patterns before words can begin to be recognized automatically.

Within this framework, Ehri and Wilce's (1983) study found that giving first and second-grade less-skilled readers practice reading familiar
words, up to 18 times, did not enable them to attain unitized response
times. The index of unitization was the ability to identify words as rapidly
as digits, symbols which it was assumed, are already unitized in memory.
The authors speculate that practice involved reading words in isolation with
no attention to word meanings. Learning words in isolation had been shown
to increase speed of identification and increase knowledge about
orthographic forms and store more complete images in the lexicon. Learning
words in context may provide more complete semantic representations
however (Ehri and Roberts, 1979).

Information-processing differences were examined in kindergarten-
level pre-readers, pre-grade two-level readers, grade two, grade four, and
adult readers. The task was to visually search for target letters appearing
in single words, pronounceable pseudo-words, and unpronounceable nonwords
and a motor response was used to indicate whether the letter had previously
occurred in a display.

Kindergarten-level children had the slowest response time and were
unaffected by the type of word. Pre-grade two children demonstrated a
word-familiarity effect as they responded faster to words, but were
unaffected by the regularities of English orthography. However, grade two
and four readers as well as adults processed words and pseudo-words just
as fast but were slower with the unpronounceable words. The adults were
faster overall. The pattern of results suggests that a significant sight
vocabulary must be established before knowledge of the regularities of
English orthography is used to facilitate perceptual processes (McCaughhey
et al., 1980; Juola et al., 1979).

There has been further research in the verbal-learning literature
regarding the development of word-naming accuracy and speed. Feustel et
al. (1983) found that words as well as orthographically-regular nonwords can have a faster and more accurate response if they were presented once previously to the subject. Therefore, the repetition effect is not exclusively related to semantic associations but to practice given to stimulus-response associations and is a function of retrieval practice.

Salasoo et al. (1985) used five repetitions of words and pseudo-words to find that both can be identified equally accurately. They argue since both words and pseudo-words can have repetition effects as codes are formed, recent (or episodic) memory serves to improve word identification. Insufficient practice at word naming may be an explanation for the poor reader's slower word-decoding rate.

Dosher (1984) examined retrieval effects when the degree of learning was varied in paired-associate words with adults. Response speed was constant for single-exposure learning but improved with repeated testing. It was concluded that only multiple exposures and not strength or duration of a single exposure will speed retrieval. Accuracy increased as study time increased but speed did not. Her findings suggest that speed and accuracy in word learning are independent of each other.

The levels-of-processing model (Craik & Lockhart, 1972), describing how information is stored and remembered, argues that people process information to the depth suggested by the demands of the task. Retention strength varies with the depth of processing, which is in turn affected by the amount of attention given to the information, its relation to existing cognitive structures, and the amount of time available for perceptual analysis and processing. If only pronunciation is required, then printed words will be encoded phonemically but not semantically. Accuracy may then be dependent upon the levels of processing. This suggests that subjects
should be required to process more than the initial or final letter of a word. The process can be assisted with visually similar distractors incorporated into the learning phase that force the learner to scan the entire display. Visual distractors share some of the original features of the previously presented word and subjects have been traditionally expected to answer whether the word is new or old.

Atkinson and Juola (1974) have used this type of paradigm to determine factors which influence speed and accuracy of word recognition. Adult subjects were asked to memorize a list of 16 to 54 words and were then tested with single words. Test items were either from the target set or were visual distractors. Response latency was measured by the time taken to press one of two keys, "same" or "different". Response time was seen to be dependent upon the number of repeated tests on a given word (up to four presentations) and on the length of the target list. Familiarity contributed to an initial fast response. When familiarity was neither high nor low, responding was seen to be delayed until an extended memory search was completed as seen by the longer latency time for a first presentation. Most of the errors to target words occurred in initial presentations whereas most errors to distractors occurred in repeated presentations. The authors reasoned, when a target item is presented for the first time, there is a high probability that an extended memory search exists before a response is given and as a result, latency is longer. The opposite was true for distractors as initial trials resulted in fast negative responses. When words were repeated, there was an increase in familiarity. With a greater number of trials, there is a longer extended memory search and response time to distractors is likely to increase.
Perfetti's (1985) verbal-efficiency theory argues that efficient lexical access is required to enable working memory to carry out propositional text. Moreover, inefficient access interferes with working memory and produces a low-quality code. If semantic or phonetic activation do not occur in parallel, a longer total access time and a fragmented word code results with its component parts out-of-phase. This can be seen in a situation in oral reading when a wrong word but phonetically similar word is produced, reflecting phonetic-semantic asynchrony. The activation of the phonological form of the wrong word is higher than the printed word. Code asynchrony is seen to be a major source of difficulty for poor readers.

What kind of model of visual-word learning and processing can account for code asynchrony?

Morton's logogen system (1969, 1979) attempts to explain how a word is made available as a response when it is identified or recognized. Each logogen is a unit of information about a word stored in permanent memory. Each logogen contains a list of features receptive to visual, auditory and contextual activation. A logogen is "fired" as its threshold is lowered by incoming information from a stimulus. Once it is fired, the logogen returns only slowly to its prior resting state. A word's resting activation level is a function of its familiarity or frequency of encounter. High-frequency words, such as "the", will have a lower threshold for activation than the word "tyn". However, when infrequent words share similar features with more common words, their logogens may be activated by mistake and slow down correct recognition. When a new or unfamiliar word is presented and not identified, the model assumes a logogen has not been fired and consequently the thresholds for all logogens are lowered
uniformly. In this case, the chance of an incorrect response will be higher than that of a correct response as the correct response may have a higher threshold for activation.

The logogen model assumes semantic input is most important for organizing the logogens because some logogens could have highly similar feature lists (write, right) with respect to either auditory or visual input. The prior presentation of an item in the same modality, visual or auditory, seems to lower the threshold much more than in a mixed modality. It appears there must be separate input logogen systems for hearing and vision. Having just heard a word pronounced does not lower its threshold substantially for visual presentation (Morton, 1979).

Anderson (1981, 1983) has proposed a theory which explains how the speed of responding to a stimulus may be developed. He suggests that the strength of a memory trace grows with study exposure and/ or practice. Once a trace is formed it remains forever but its strength can grow or decay with time. Each of the nodes in a trace is connected to many other nodes. Activation always spreads from source nodes to all traces associated with the stimulus. Source nodes are those memory nodes in a given trace that receive direct stimulus input. The amount of activation across a trace is dependent on the strength of its memory nodes. Increases in nodal or overall trace strength result in improvements in recognition or recall-memory accuracy and retrieval or response speed. Time to retrieve a trace depends on its level of activation. Anderson suggests that response latency and accuracy do not reflect exactly the same properties of a memory trace. There were still reaction time differences between paired-associate naming tasks, with and without interference from a previously learned list, even though percent recall and recognition were equated.
Ehri and Wilce (1983) have addressed word learning in their three-phase model. Their cross-sectional approach infers the cause of change between stages, however. Some of the gaps in their model can be addressed with data from visual-word learning experiments. Specifically, it is of interest to determine how the variables of speed and accuracy interact in phase one of reading vocabulary acquisition. Their model seems to separate the variables of accuracy in phase one and speed in phase three. Moreover, the interaction of these variables may explain what the reader does when he/she reads a word. This in turn may determine what is encoded about that word for a given trial. With repeated presentations of a word, the processes of encoding and decoding may be more clearly distinguished than are presently.

It may be that disabled readers engage in single-code processing rather than dual-code processing when learning new reading vocabulary words (Wagner, 1983). Visual-word learning requires both within-code elaboration learning and between-code association learning. Within-code learning refers to establishing visual, auditory and semantic features of a word. Between-code learning refers to learning auditory-visual, semantic-visual, and auditory-semantic associations.

Wagner's (1983) results indicate that disabled readers tend to concentrate on visual-perceptual learning instead of developing associations between visually-encoded information and auditory and/or semantic codes. However, when the design was such that the reader was given no other options but to use phonological processing, he did so. This finding suggests that word identification is dependent on how the reader's attention is distributed between the two kinds of learning. Both types of learning may be used over the entire period of word acquisition or the
reader may choose to allocate his attention to one type of learning initially and then switch to using an alternate strategy.

Visual-word learning is seen to involve visual-feature learning, lexical-association learning, and trace strengthening (Wagner, 1985). Visual-feature learning may begin by discriminating a familiar element such as an initial or final letter in a new word. It is then associated with the name of the visual stimulus stored in long-term memory. Errors can result from other words retrieved which begin or end with the same letter. This stage is measured by the ability of a reader to retrieve the name of the word.

As discrimination of the remaining elements of a word becomes more exact, one or more lexical components of a word are associated with the word's name, phonemes, or meaning in long-term memory. Recognition memory is seen to be an index of visual-feature learning while accuracy reflects the number of associations made between the visual features and lexical components of a word. Response time is an index of the strength of the stimulus and response association.

The first phase of word learning in Ehri's (1980) and Ehri and Wilce's (1983) model is regarded as a process of paired-associate learning. The process requires stimulus encoding, response learning and stimulus-response integration (Samuels, 1973). Stimulus encoding requires learning the visual features of a given word. Response learning refers to the learning of the name, semantic features and auditory features of a word. Stimulus-response integration refers to a process whereby any component of word's lexical structure can be mapped onto the visual stimulus. This could be the name of the word without attention given to the phonetic
structure. Alternatively, when reading in context, the meaning may be associated with the visual stimulus in long-term memory.

When learning a new reading word, it is hypothesized that its name is first retrieved from long-term memory and placed in the rehearsal buffer of auditory short-term memory and retained there while the word is being learned (Nairne, 1983). At this point, the reader may engage in both visual-feature learning and lexical-association learning. Visual-feature learning may consist of encoding one or two of the attributes of the visual stimulus while lexical-association learning is required to link the name of the word or the word's sounds or meaning with the encoded features of the visual stimulus. This association is formed when both the name and encoded visual features are in working memory at the same time and this results in the storage of a single cognitive unit in long-term memory (Anderson, 1983). It follows that the reader must keep the name (or sounds or meaning) of the word active in the rehearsal buffer of short-term memory while giving attention to the encoding of visual information.

With subsequent presentations of a word, it is hypothesized that learning continues in a number of ways. Each time the word is read the visual features stored in long-term memory, or the visual logogen (Morton, 1969), are activated and strengthened. The amount of activation is a function of the match between what is stored in long-term memory and the incoming visual information. Activation spreads from the visual logogen to the name logogen of the word as a function of the number and strength of the associations established during the first and subsequent learning and/or response trials (Anderson, 1983). More numerous and stronger visual-name logogen associations result in faster name retrieval the next time the word is read.
It is possible of course that context may not always provide enough information to identify a word correctly and that there may be a need to encode more visual features. With repeated presentations of a word there is the opportunity to learn or acquire more of its visual features. In this case, additional formations of an association between a visual feature in the visual logogen of the word and the word's name would result. Each time new visual-feature information is added to the logogen structure of a word, the subject must engage in both visual-feature learning and lexical-association learning concurrently while the word's name is retained in auditory short-term memory.

It is assumed that lexical-association learning requires more cognitive effort or central-processing capacity than either visual-feature learning or trace strengthening (Guttentag, 1984; Case, 1985). Retaining newly encoded visual features in working memory on the other hand, should be supported by the presence of the visual stimulus and trace strengthening is an automatic by-product of reading practice (Anderson, 1983). Lexical-association learning can be viewed as cross-modal or between-code processing as it requires the mapping of auditory or semantic codes onto a new visual stimulus.

Within this framework it is hypothesized that poor readers may have to give more attentional capacity to maintaining lexical information in working memory than normal readers and may be less successful at doing so. Lexical information which is less meaningful or familiar, and of a poorer quality code, may be harder to retrieve from long-term memory and retain in short-term storage (Vellutino, 1979; Perfetti, 1985). There is also evidence that poor readers are weaker in linguistic-coding tasks than normal readers when verbal rehearsal is not possible (Swanson, 1983).
Furthermore, the reading disabled tend to engage in significantly less spontaneous verbal rehearsal to maintain information in short-term memory (Torgesen and Goldman, 1977).

It will be assumed, then, that the disabled reader has difficulty placing and maintaining lexical information in working memory and this interferes with forming strong and elaborate lexical-visual associations. It may also interfere with visual-feature learning if attention is diverted to maintaining lexical information in short-term storage rather than isolating visual features and storing them for lexical-association learning.

Wagner (1983, 1985) has argued that visual-feature learning, lexical-association learning and trace strengthening are independent. Implied is the argument that the reader has to coordinate these processes when learning a new word. It is hypothesized that poor readers have difficulty achieving a balance between these types of learning and that as a result there is asymmetry between the nodes in a given logogen (Perfetti, 1985).

It is possible for a reader to adopt a couple of strategies during the process of learning a new word. If only the first and last letters of a word are encoded and associated with its name, trace strengthening would still occur each time the word was correctly identified. This results in an increase in speed but leaving accuracy relatively unchanged. An alternate strategy may be to improve accuracy and extend the number of lexical-visual associations if a reader were to concentrate on associating letters to specific phonemes within a word’s name. As a result, lexical-retrieval speed does not improve.
Predictions:

Within the framework of visual-word learning, the following predictions can be made:

(a) The poor reader may be both less accurate and slower in naming speed than the normal reader. The lower accuracy may be a result of fewer lexical-visual associations and the lower speed or vocalization latency is a result of less activation coming from the visual logogen to the lexical and response logogens. Lower accuracy may also be caused by less visual-feature learning per trial. If this is the case, recognition-memory accuracy per trial is expected to be lower for the poor reader as well. Implied is the prediction that the poor reader will learn the word more slowly than the normal reader.

However, it is more difficult to make precise predictions about the nature of the slopes of the speed and accuracy learning curves. Normal and poor readers may start out with different amounts of pre-experimental learning. For example if (sh) is already familiar to a normal reader, fewer visual-feature and lexical-association learning trials will be required to learn (short) than a poor reader unfamiliar with these letter clusters (Samuels, 1973). In this instance, the normal reader will begin learning the letters and letter patterns which are more difficult and occur at a lower frequency. As the rate of learning unfamiliar and less frequent letter and letter patterns should be slower than the rate associated with relatively easy high-frequency orthographic units, poor readers may show a steeper learning curve than good readers (Newell and Rosenbloom, 1981).
(b) A second possibility is for the poor reader to maintain accuracy at the same level of the good reader but be slower in vocalization latency. This may occur if the poor reader establishes the same number of lexical-visual associations per word on a given trial as the normal reader but forms associations which are weaker in strength. Strength in this case would be a function of the number of times a given trace was employed in word identification. In this scenario, visual-recognition accuracy should be the same for both the normal and poor reader. The effect of pre-experimental learning may enhance accuracy and recognition-memory accuracy for the normal reader throughout the experimental trials. Again, the normal reader’s word-identification speed might improve at a slower rate than the poor reader’s if he/she continues to sample low-frequency visual-features.

(c) More likely is the possibility that the normal reader establishes both more numerous and stronger lexical-visual associations than the poor reader. Anderson’s (1983) theory maintains that a subject can increase the trace strength of a specific letter-name association by repeating the association process and adding redundant associations to it or by increasing the total number of letter-name associations. Activation may spread from a partially complete visual logogen such as (bl) for the visual stimulus (blew) to a partial or incomplete set of visual-name associations such as b-blew, l-blew. These associations may be strengthened and be retrieved faster even though the subject’s knowledge of the word’s orthography is incomplete. In this case, the poor reader is expected to be less accurate and slower in speed per trial as a result of fewer and weaker lexical-visual associations. The results would be similar to the first case described, however, the weaker trace in this prediction should magnify the difference in speed.
between the two groups. Again, pre-experimental learning may act to produce a shallower slope for the normal readers' rate of learning. However, it is difficult to predict the poor readers' rate of learning as the slope in this case may depend in part on the amount of rehearsal the subject is willing to engage in during a given experimental trial.

In order to test these predictions it was necessary to assess the performance of normal and poor readers on three variables as they learned or acquired new reading words over at least thirty trials. It is important to note that to the best of this researcher's knowledge, visual-word learning or the acquisition of new reading vocabulary has not been assessed over eighteen learning trials. The variables were (a) oral-reading vocalization latency, (b) oral-reading accuracy, and (c) visual-recognition accuracy. Oral-reading vocalization latency was used as an index of lexical retrieval or word-identification speed and oral-reading accuracy was used as a measure of the number of lexical-visual associations the reader had established. Recognition-memory accuracy was viewed as a measure of the amount of visual-feature learning that had occurred for a given word independent of the lexical-visual association that may have been established. All three measures were taken each time a stimulus word was read.

In addition, a variable was added in the form of phonetically-regular and irregular words in order to see whether the presence of regular orthography and/or regular-phonetic relationships would facilitate visual-feature learning and/or lexical-visual association learning in either type of reader. It was hypothesized that poor readers would demonstrate longer vocalization latencies than the normal reader group for both phonetically-regular and irregular words. Within the poor reading group, individual
differences should exist such that some phonetic readers and spellers will learn phonetically-regular words at a faster rate than other poor readers who rely more heavily on a whole-word approach. Normal readers should be more flexible and not demonstrate a word-regularity effect.

Subjects:

Subjects were 20 third and fourth graders, ten normal readers and ten disabled readers. Parental consents were obtained for all subjects, who were tested during the summer months at Brock University’s Reading Clinic. Transportation was provided for each participant.

Within the normal reader group, there were seven males and three females. Ages ranged from 10 years 9 months to 9 years 0 months with a median age of 9 years 10 months.

Normal readers were selected at random from a pool of children who were identified as reading at or above grade level by their teachers at three local elementary schools. Eight students had just completed grade four and two had completed grade three with the average grade being 4.7.

Normal readers had an average oral-reading grade on the Durrell Analysis of Reading Difficulty at a mid-grade-four level (.573 secs. per word in passages with at least 80% comprehension) while silent-reading levels on the Durrell were at a high-grade-four level. The mean IQ, as assessed by the IPAT Culture Fair Test of Intelligence was 113.3 (range 95-127).

Disabled readers were selected during their summer school special education program. Teachers had identified these students, who were from various local elementary schools and class placements, to be reading two years below their expected grade and age levels. All subjects were given a
screening test and those scoring at least 90 points on the Culture Fair Test of Intelligence and who were at least two years below their expected grade levels on the Durrell Oral and Silent-Reading Tests were included.

The poor reader group consisted of six males and four females with ages ranging from 9 years 11 months to 11 years 4 months (median 10 years, 1.5 months). Mean IQ was 99 (range 90-108). Average oral-reading grade level was at low-grade-two (.829 secs. per word) with silent-reading levels also at low-grade-two.

Spelling grade levels were also collected for both groups of readers using the DST: Spelling Test (Gnagey, 1976). Normal readers achieved an average grade level of 7.1 for phonics words (range 5.3-8.5) and an average grade level of 6.0 for sight words (range 4.7-8.2). Poor readers achieved a grade level of 4.4 (range 1.5-6.3) for phonics words and an average grade score of 3.4 (range 1.5-5.2) on the sight-word list.

All subjects were native English speakers, had normal or corrected vision and hearing, and had no diagnosed emotional, sensory, or neurological impairments.

Materials and Apparatus:

The stimuli were taken from graded word lists in the Classroom Reading Inventory Manual (Silvaroli, 1965). Words were defined as "known" if subjects could correctly identify a word by pronouncing it correctly and by expressing knowledge of its meaning through a suitable verbal sentence. Words were defined as "new" if the student was not able to decode or pronounce a visually presented word yet could explain the meaning of a word when presented orally by the examiner. Consequently, word-identification
experience was a controlled factor. Word length ranged from four to nine letters with only two-syllable words included for presentation.

Each subject received two new individualized eight-word lists to be read aloud. One list contained irregular new words which required the recognition of conditional relationships between spelling patterns and atypical pronunciation of at least one of the spelling patterns (Venezky, 1970). The second regular-word list contained basic phonics and predictable letter-sound correspondences. A third "baseline" list of known, two-syllable words was derived consisting of four phonics words and four sight words. These were one to two years below the subjects' current oral-reading level and were used to determine a subject's ultimate response time.

Visual distractors were utilized in half the number of trials in the new word lists. They were derived by changing one letter at various positions within the word but the first or last letters of the target word remained unchanged (e.g., salmon for salmon). The distractor always remained pronounceable.

All stimulus words were typed in lower case letters and presented in the centre of a Commodore 64 colour monitor for a maximum of 5.0 seconds. Responses were made with a microphone connected to a voice-operated relay. Response latency was recorded by the computer on each trial. Timing began with the onset of the stimulus word and ended with a vocal response by the subject. The voice-operated relay system itself was assessed as using 50 msecs. to complete the process.
Procedures:

Pilot Study

A pilot study was conducted with eight students, four average readers (two males and two females) and four poor readers (three males and one female). The four average readers were enrolled in a regular grade-four class, and were tested daily at their school for four days with sessions lasting 30 minutes. Poor readers were enrolled at the Brock University Reading Clinic and testing was carried out concurrently with their on-going reading assessments but on a weekly basis.

There were three purposes of the pilot study. First, it was necessary to determine expected vocalization-latency response times for average reading nine and ten-year-old children with the apparatus being used in this study. Second, it was necessary to determine if these response times would decline with repeated presentations of familiar words and new words above the subject's grade level. Third, the required number of word presentations to reach asymptote levels of reaction times had to be determined.

Subjects were given four two-syllable words (two phonics and two sight) and four distractors. Distractors were derived by changing one letter in the target word. These eight words appeared on the computer screen for two minutes. The experimenter read each word aloud and asked the subject to repeat it. The subject was also required to explain the meaning of the target words. If unable, another word was substituted. A one-minute activity game followed to prevent rehearsal. A "get ready" signal ensued remaining on the screen for five seconds followed by the target or distractor word which also appeared for a maximum of five seconds. Words were arranged in random order with a target word appearing at least once
every six trials. During this pilot testing the list of eight words was presented six times for a total of 48 trials.

Results of the pilot testing yielded the following: For average readers, response times for words two years above the subjects oral-reading level ranged from 1.325 secs. (averaged across three initial presentations) to .709 secs. (averaged across three final presentations) after 36 trials. There were individual differences such that some readers required four consecutive trials to reach their fastest time for a particular word while others required thirty trials. There appeared to be variation according to motivation such that the final trials did not always produce the fastest times. Times for distractors ranged from 2.001 secs. initially to .838 secs. after 36 trials.

Poor readers tended to read faster initially (1.192 secs. after three presentations) and with less pronunciation accuracy (50%) and did not decline as sharply in speed (.976 secs. after 30 trials). Recognition accuracy also appeared lower than that of the normal readers as poor readers did not often realize that a distractor was presented and continued to read the distractor as the target word.

About 10% of the trials could not be included due to difficulties with the voice-activation switch or because of the subject triggering the device by fidgeting or producing some other sound that triggered the sound switch. The data from the pilot subjects was not included in the final analysis.

Experiment:

Alterations to the pilot procedure included: 1. Incorporating six practice trials with a separate word list in order to set appropriate amplification control settings and reduce the number of lost trials. 2.
Defining "new words" as those the subject could not pronounce when given a "new" list beforehand rather than assuming that words two years above his current reading level were "new".

3. Increasing the target list of words from four to eight with each subject receiving individualized lists of eight phonics words and eight sight words thus reducing the chances of retaining the order of the word list in short-term memory as well as reducing the chances of word-type effects to be based upon a closed set of words.

4. All readers were given 30 trials of each word.

Five to seven consecutive days were required to test each subject individually. Day 1 involved administering the reading, spelling and IQ tests and forming the word lists. The Durrell Oral-Reading Test was used to compare time-per-word in printed context to VL to familiar and unfamiliar words presented in isolation on the computer. Days 2-6 (normally) were spent with the word lists with the order of presentation counterbalanced between subjects. Half the subjects received the baseline list of familiar words first and half the subjects received the phonics-word list first. The number of trials completed daily varied among individuals as each reader progressed at his or her own pace. Generally, three to five blocks of trials were completed daily with a block of 48 trials taking anywhere from four to 15 minutes, depending on the skill of the reader. Total time spent in daily sessions averaged 1 1/2 hours.

During the word-learning conditions, visual distractors appeared randomly in half of the presentations with a target word appearing at least once every six trials. After the word or nonsense word appeared, and the subject had pronounced it, he was asked whether there had been any change in the spelling of the word. The subject was required to state "yes" or "no" and recognition accuracy as well as pronunciation accuracy was recorded by
the experimenter. Feedback by the examiner was given to correct mispronunciations by pronouncing the word properly, after the subject responded to the recognition-accuracy question. Feedback was also given in instances where recognition errors occurred with the examiner stating that there was an error, although the change was not pointed out specifically. Throughout the presentations, subjects were encouraged to "say it as fast as you can" with frequent responses of "good work" given. Rest periods between blocks of presentations were provided as the students could play computer games on another computer in the clinic. Poor readers, who tended to have shorter attention spans, were often given more rest periods than the good readers. All subjects were given treats as rewards upon completion of each session.
Pre-Treatment Characteristics:

Results of the IPAT Culture Fair Test, a measure of nonverbal-reasoning ability, yielded differences in performance between the groups $F(1,18)=12.139$, $p<.01$. Poor readers scored within the average range of intelligence ($X=99.0$) and the good readers within the high-average range ($X=113.3$).

Groups differed significantly in their vocalization latencies (VL) to familiar, baseline words. This was true for phonics words $F(1,18)=5.125$, $p<.05$ and for sight words $F(1,18)=9.708$, $p<.01$.

Within-group comparison of mean response latency to baseline words indicated poor readers were not significantly different in vocalizing sight words (1.006 secs.) or phonics words (1.096 secs.). This was the case for good readers as baseline VL were similar for sight words (674 secs.) and phonics words (.736 secs.).

Oral-reading rate (time-per-word) within context on the Durrell was faster for good readers ($X=.592$ secs.) than for poor readers ($X=.826$ secs.), $F(1,18)=12.355$, $p<.01$. Time-per-word was calculated by dividing the total time required to read a graded passage by the total number of words, with a word being five characters. The total number of words was calculated by dividing the total number of characters by five. This was to control for the words encountered at the grade 1 and 2 level passages which tended to have shorter one-syllable words. The difference also was significant when words were not altered $F(1,18)=30.294$, $p<.01$. Good readers averaged .447 msecs. per word while the poor readers averaged .666 msecs.
Good readers read orally at a mid-grade-four level while poor readers read at a beginning-grade-two level, a difference which was statistically significant $F(1,18)=36.368$, $p<.01$. Silent-reading rate for good readers was at a high-grade-four level and at a low-grade-two level for poor readers, the difference also being significant $F(1,18)=40.726$, $p<.01$.

Spelling achievement differentiated the two groups. Good readers performed better on phonics words $F(1,18)=18.918$, $p<.01$ ($X=$ grade 7.1; 4.4) and on sight-word lists $F(1,18)=6.306$, $p<.025$ ($X=$grade 6.0;3.4). Within-group comparison did not produce differences on the two types of lists.

Experimental Results:

Word-naming latency scores were calculated for each subject for all experimental conditions. As each target word appeared three times per block of trials, averages were used to compute mean scores.

A mixed ANOVA design was used with one between-subject factor (reading ability) and two within-subject factors (word type and practice). Latencies for which the response was incorrect were not used. In addition, trials on which the response was correct but did not stop the timer, or on which the timer was stopped by a sound other than the name of the word, were eliminated. These procedures resulted in missing latency values for individual subjects approximately 6% of the time.

Separate analyses for word-naming latency (reaction time), accuracy and recognition scores were computed for target words and distractors.

Target Words:

Normal readers were significantly faster than poor readers in their vocalization responses to target items across trials. There was a
significant main effect for reader ability $F(1,18)=13.475, p<.01$ and for practice $F(1,18)=14.833, p<.01$.

Reaction-time differences resulted in significant interactions between reading ability and practice $F(1,162)=2.252, p<.05$ as well as word type and practice $F(9,162)=2.539, p<.01$. However, there was no significant effect of word type, nor an interaction of reading ability, word type and practice. See Figures 1, 2, and 3.

Good readers were more accurate in pronouncing the target words than poor readers. There was a significant main effect of reading ability $F(1,18)=4.421, p<.05$ and of practice $F(9,162)=5.421, p<.01$. There was a significant reading ability by practice interaction effect $F(9,162)=2.949, p<.01$. However, there was no main effect for word type, nor were there any two-way or three-way interactions occurring with word type.

Good readers were better at recognizing new words. There was a main effect of reading ability $F(1,18)=9.962, p<.01$ and for practice $F(9,162)=16.414, p<.01$, as well as a significant interaction with reading ability by practice $F(9,162)=6.420, p<.01$. Again there was no main effect of word type, nor interaction with the other two factors.

**Distractor Data**

Good readers were faster in their VL to distractor items than poor readers $F(1,18)=11.314, p<.01$. Both groups improved across trials $F(9,162)=10.888, p<.01$. Good readers did not differ in respect to VL to target words and distractor stimuli whereas poor readers were slower on distractor items than on target words $F(1,18)=8.091, p<.01$.

Good readers were more accurate in pronouncing distractors. There was a main effect for reading ability $F(1,18)=10.11, p<.01$, main effect for
Figure 1
Phonics and Sight-Word Vocalization Latency

Sight Words
Phonics Words
Figure 2
Normal Reader Target Vocalization Latency to Phonics and Sight Words

Phonic words
Sight words
Figure 3
Poor Reader Target Vocalization Latency to Phonics and Sight Words
practice $F(9,162)=21.827, p<.01$, and a slightly weaker effect for word type $F(1,18)=6.239, p<.025$.

Poor readers were more accurate with phonics distractors than with sight distractors. There was a significant interaction with reading ability by word type $F(91,15)=5.149, p<.05$ and reading ability by practice $F(9,162)=6.176, p<.01$ as well as a word type by practice interaction $F(9,162)=2.319, p<.025$. Reading ability by word type by practice interaction was not significant.

Distractors were recognized correctly more often by good readers $F(1,18)=9.397, p<.01$. There was a significant interaction with reading by practice $F(9,162)=4.822, p<.01$. Groups did not differ according to word type as there was no significant two-way or three-way interactions with word type.

**Description of the Target-Word Learning Curves:**

As demonstrated in the line graphs, good readers were able to reduce VL time by 275 msecs. after 30 trials (973 msecs. to 698 msecs.) whereas the poor readers declined by 455 msecs. (1,797-1,342). This pattern suggests the poor readers were actually learning faster than the good readers. See Figure 4.

Post-hoc analysis was conducted using the power law of practice (Newell and Rosenbloom, 1981). Plotting the logarithm of the time to perform a task against the logarithm of the trial number yielded a straight line. The linear regression equation for the good reader group was $y=-.1385 (\log x) - .0283$ and for the poor reader group was $y=-.1426 (\log x) + .2540$. The difference in the slopes confirms the poor reader group to be progressing at a faster rate. See Figure 5.
Figure 4
Normal and Poor Reader Target Vocalization Latency As A Function of Practice
Figure 5
Logarithms of Reaction Time and Trials for Normal and Poor Readers

Slope = -.1385
Normal Readers
\[ y = -.1385 \log(x) - .0283 \]
\[ y \text{ intercept} = -.0283 \]

Slope = -.1426
Poor Readers
\[ y = -.1426 \log(x) + .2540 \]
\[ y \text{ intercept} = .2540 \]
The sharpest decline on the graph occurs between blocks 1 (after 3 trials) and 2 (after 6 trials). Poor readers reduce their time by 200 msecs. and continue to lose a further 344 msecs. between blocks 2 and 8. Blocks 8 to 10 actually result in an increase of 92 msecs.

Good readers reduced their time by 150 msecs. between blocks 1 and 2 and lost a further 124 msecs. between blocks 2-10. There is continued improvement until the eighth block by an average of 39 msec. before the first increment. It is at the eighth block where the gap between groups is the smallest (550 msecs.) as compared to the 824 msecs. difference initially. See Figure 6.

Poor readers show a greater fluctuation in VL between blocks and differ significantly from the good reader group in their standard deviations from the mean at each interval F(1,18)=77.294, p<.01. See Figures 7 and 8.

Baseline vocalization times of each subject were subtracted from the time established at the thirtieth trial on each list in order to determine whether differences could be attributed to individual slower naming speeds. Good readers most closely approached their baseline rates on the phonics list F(1,18)=8.414, p<.01. Good readers came within 11 msecs. while the poor readers still were 290 msecs. from their baseline rate. There was a similar trend on the sight-word list (good readers=45 msecs.; poor readers=276 msecs.) though this was not statistically significant. When absolute values were analyzed, good readers did differ on the sight-word list F(1,18)=4.865, p<.05.

Four of the ten good readers established values actually lower than their baseline times on the sight-word list as did nine out of ten on the phonics list. In the poor reader group, one subject was actually faster than the baseline rate on the sight-word list and three were faster on the
Figure 6

Differences Between Normal and Poor Reader Target Vocalization Latency As A Function of Practice
Figure 7
Target Response Latency (Normal Readers)
Figure 8
Target Response Latency (Poor Readers)
phonics list. Within-group comparison did not establish differences on the two word lists for either group.

In summary, both groups showed increases in VL when familiar words were presented in isolation from the time per word in the context condition. Good readers gained 113 msecs. and poor readers gained 225 msecs. After 30 presentations of a new word, good readers came within 7 msecs. of their baseline rate whereas poor readers were still 291 msecs. away. This difference was smaller after 24 presentations as good readers came within 5 msecs. and poor readers within 92 msecs. However, the poor reader group learned new words at a faster rate in terms of the decrease in response time across trials.

**Description of Accuracy and Recognition Graphs:**

Both groups demonstrated relatively high accuracy and recognition scores although the good readers fared better in both measures. Good readers maintained a range from 96% to 98% accuracy and a range of 95% to 100% recognition. See Figure 9.

Poor readers were somewhat lower but maintained a range of 86% to 97% accuracy and 82% to 98% in their recognition scores. Both groups show the largest gain between the first and second block of trials at which point performance ceases to improve more than a few percentage points. See Figure 10.
Figure 9

Accuracy and Visual-Recognition Memory Scores for Normal Readers

Accuracy

Recognition

Trials

Percentage
Figure 10
Accuracy and Visual-Recognition Memory Scores for Poor Readers
CHAPTER FIVE

DISCUSSION

Disabled readers were slower than normal readers in word-naming speed and were less accurate in reading and recognizing new reading vocabulary words. There was no word effect according to phonetic regularity for either group.

Normal readers were able to surpass their typical reading rates to familiar words by 5 msecs. after 24 repetitions of a new word whereas poor readers were still 92 msecs. from their ultimate reading rate. Continued repetitions to 30 trials served to increase vocalization latencies. Normal readers reduced their VL by 2 msecs. between trial 24 and 30. Going from reading in context in the pre-test condition to reading familiar words on a computer served to increase time-per-word for both groups but the poor group increased twice as much time than did the normal readers.

The results suggested that both normal and poor readers engage in visual-feature learning, lexical-association learning, and trace strengthening when acquiring new reading vocabulary. Both groups were able to achieve and maintain high levels of accuracy and word recognition while vocalization latency continued to improve at a slower rate. Interestingly, the largest decreases in vocalization latency occurred in the first three to six trials for both types of readers. Implied is a model in which the speed of lexical retrieval begins developing with the first lexical-visual associations that are established and does not wait for the achievement of complete accuracy. Speed may thus be incremented through trace strengthening as a function of reading practice on those components.
of the logogen already in long-term memory while new components are being
added on.

The high visual recognition-memory scores of the normal readers were consistent with the prediction that normal readers should be better at encoding visual-feature information than poor readers. This was also consistent with the pre-treatment observation that the normal readers performed significantly better on the IPAT Culture Fair Test of visual-spatial reasoning, although both groups were in the normal range. The lower visual recognition-memory scores of the poor readers suggest that as they were engaging in less visual-feature learning per trial than the normal readers, fewer visual features may have been available in short-term memory for lexical-visual association learning. The lower reading-accuracy scores of the poor reader group were also consistent with the prediction that fewer lexical-visual associations were being formed per trial. Normal readers appear to have begun with and developed more lexical-visual associations than the poor reader as indexed by both their higher visual recognition-memory performance and their reading-accuracy scores.

Performance in visual-recognition memory and word-identification accuracy appeared to asymptote between the sixth and tenth trials for both groups, thus suggesting that visual-feature learning and lexical-association learning is complete long before maximum word-identification speed is achieved. However, not changing the three forms of distractors across blocks may have contributed to these patterns. It might be that these levels represent the point at which further visual-feature learning and lexical-association learning was not required to discriminate the stimulus words from the distractors in this experiment. Had the distractors contained letter-order changes as well as letter-item changes, recognition
and accuracy-performance levels may have taken longer to asymptote. Of course, visual-feature learning and lexical-association learning may have continued after the tenth trial but at a slower rate. The rate of learning in both cases would be slowed down by the lack of specific feedback on errors and the fact that visual-feature learning and lexical-association learning would require the isolation of increasingly less familiar and less frequent stimulus information (Newell and Rosenbloom, 1981).

This interpretation is consistent with the word-identification speed or vocalization-latency data. Both groups continued to improve in speed from the twelfth to about the twenty-first trial. Some of this improvement may have been the result of trace strengthening from reading practice. However, the fact that these curves also came to an asymptote at around the twenty-first trial mark suggests that the subjects may have reached a point where further or additional visual-feature and lexical-association learning may have been too difficult. Poor readers not only started with very long vocalization latencies but came to an asymptote at a much higher or earlier level than the normal readers. Combined with the finding that their curve was steeper than that of the normal reader, it appears that the poor readers began their learning by acquiring much more familiar stimulus information than the normal readers but exhausted this information somewhere around the twenty-first trial. The normal readers appeared to begin their learning with a certain amount of pre-experimental knowledge of the stimuli and as a result, moved more quickly into relatively low-frequency stimulus information. They appeared to be sampling less familiar, higher-level chunks of stimulus information (Newell and Rosenbloom, 1981). This process is illustrated in Figure 11. This type of information might have been more difficult to isolate and encode as well as more difficult to form.
Figure 11
Encoding Strategies of Normal and Poor Readers as Predicted by The Power Law of Practice (Newell and Rosenbloom, 1981)

Poor Reader

Normal Reader

"pilgrim" (visual stimulus)
lexical-visual associations. In addition, the assymptotes of the normal readers' learning curves may in some cases represent the limits of word-naming speed in this type of experimental setting.

The phonetic regularity of a stimulus word did not produce differences in speed, accuracy or recognition memory for either group although the effect was seen in faster speed and higher accuracy scores when pronouncing phonics distractors, particularly within the poor reader group. To some extent, poor readers were slower in identifying phonetically-irregular words in the first block or two, as shown on the line graph (Figure 3). However, after the sixth to tenth trial there were no observable differences. It is possible that the procedures of the experiment may have been the cause of this effect as the recognition-memory question in effect asked the subjects to look at the stimulus word a second time and may have encouraged more analytical processing than is normally associated with a single reading response. Consequently, the poor readers in particular may have engaged in more analytical processing than they do when reading word within the context of a standard reading program.

Another possibility may be that the sample size used in this study was not large enough to clearly establish a dysphonetic or dyseidetic group. Neither the normal nor the poor readers showed any difference in their pre-treatment vocalization latencies for irregular and phonics words. This may have been an artifact of the stimulus selection procedure and a failure to control for word frequencies. Although the words were at least one grade level above each reader's assessed reading-grade level, they may have consisted of simpler, more familiar orthographic structures than are normally encountered in a reading program. This may have contributed to, in part, the steeper slopes in the poor reader's learning curve. On the other
hand, the poor readers in this sample may have been representative of readers more flexible in their decoding ability as Mitterer (1984) suggests.

The absence of a regularity effect also seems to support Perfetti's (1985) theory that reading ability will range on a continuum. Low-ability readers as found in a regular classroom and dyslexics may differ mainly in the quantity of reading difficulties and not in a distinctive qualitative sense. The SLD group showed a longer decoding time even when accuracy was high, which suggests that difficulties may remain in associating a verbal code with a word rather than at the visual-spatial level.

The assumption of this study was that skill at recognizing words relates to reading ability and that recognition speed facilitates reading comprehension. Word identification is only one component of the reading process. Syntactic and semantic context use and reading comprehension are processes of equal importance which may produce a different pattern of results if vocalization latencies are measured. Ehri and Roberts (1979) suggest readers learn more about a word's internal structure when the word is presented in isolation but more about its semantic and syntactic value when presented in context.

Another underlying assumption of the study was based on Laberge and Samuels' model that allocation of attention to word decoding may slow down reading rate and strain comprehension if words are not identified automatically. The purpose of over-learning a lower-order skill in this study was not to demonstrate automaticity. The study did not use a paradigm in which the subject was asked to perform two simultaneous tasks with one that involved conscious attention and one task that did not. Rather, the long vocalization latency performance scores can be interpreted as predictive of the comprehension difficulties the poor reader can expect.
The design of this study entailed matching groups for age rather than reading-grade level. The disadvantage of this design is that the normally progressing group probably has a greater experience with text than the group delayed in reading progress. Because the two groups were matched for age, there may have been an insufficient repertoire of sight vocabulary built up in the poor reader group. Future experiments may want to replicate the study with groups matched on reading-grade level.

The vocalization latencies were similar to times reported in previous research with this population. The possibility exists that fatigue effects were responsible for limiting reaction-time performance because of the number of trials presented. Continuing beyond thirty trials is a possibility if a different design is used to avoid fatigue. Future studies may seek to determine whether the same fluctuating pattern of vocalization latencies in the poor reader group is demonstrated if the number of trials is extended. Although the majority of the subjects were demonstrating a ceiling effect after thirty trials, the possibility exists that a few may have continued to improve.

Nevertheless, the findings of this research have strong implications for psycho-educational assessment and teaching instruction. Often word-decoding ability is assessed by simply having the student read the word correctly. A common educational assessment procedure used by diagnosticians is to have the student orally identify isolated words and associate the total accuracy score with a reading-grade level equivalent score. Processing rate and number of trials to criterion are ignored variables which can complement the assessment of reading disorders. The findings suggest that accuracy and recognition-memory scores are insufficient to assess total word-decoding ability. Vocalization latency
seems to be a more sensitive indicator of a student's speed of processing a visually-presented display.

Not identifying or including processing rate can have further implications in the case of possibly misdiagnosing a learning disabled reader as normal when he or she achieves a high accuracy score. In an alternate scenario, the student placed in a special education class of low enrolment who is then given a word-decoding test may again achieve a high accuracy score. If the processing speed is not taken into account, the results would yield an inflated grade-level achievement score which could be interpreted as meaning that the student is ready to be placed back into a regular classroom.

Presently there are methods of evaluating reading rate through timed graded passages which the student is asked to read silently or orally. The outcome gives the teacher or diagnostician an average time-per-word or a measure of the number of words read-per-second. The procedure does not account for the evaluation of the specific words which are most problematic for the reader. This lack of a suitable measurement device contributes to the difficulty in evaluating the words or groups of words which are specifically problematic for the reader. The use of a microcomputer in the classroom can assist the teacher in the on-going assessment of reading achievement. Three to six presentations would yield results that could be compared to the pattern of vocalization latencies that were found here for normal and poor readers identifying familiar reading vocabulary. The normal reader demonstrated a consistent increase in speed while the poor reader was much more variable. Normal readers ranged from 973 msecs. to 698 msecs. while poor readers were in the range of 1,797 msecs. to 1,342 msecs.
Teachers often assess reading performance by ongoing evaluation of isolated word recognition and the danger exists that students are not likely to receive enough practice in developing reading speed. The computer program used in this study can be encorporated into the pedagogical format of introducing new reading vocabulary to the student before he or she is asked to read the new word when presented in a passage. The student should be asked the meaning of the word and if unknown could practice the word by using it appropriately in context. The group of words can then be presented on the screen and studied for two minutes followed by individual stimuli of target words and visual distractors. Practice sessions of nine to twelve trials may be sufficient to yield a high-level of accuracy and lower vocalization latencies in the normal reader to ensure that word-identification practice include not only practice for accuracy training but for improving processing rate.

The relatively long latencies demonstrated by the poor reader group suggest a problem for the teacher in the sense of devising methods for improving this reading skill. The assumption may be that the disabled reader does not profit from the type of instruction or feedback given in this task as does the normal reader. Critical letter changes were not pointed out specifically to subjects in the recognition-memory task although mispronunciations were corrected. Perhaps a highly systematic way of continuously altering distractors would bring attention to what is visually encoded. However, failure to reduce reaction time to the level of the normal reader suggests the speed of accessing the names of the words in memory may not depend on the amount of practice or familiarity with the visual items being encoded.
Jackson and McClelland (1975) are in accordance with the view that better readers probably have faster access to information in memory for visual symbols. In tachistoscopic tasks where a string of unrelated consonants were presented, good readers could report more letters than poor readers from the briefly presented string. Differences were not attributed to disparities in short-term memory capacity or the visual sensory function. It appears good readers probably analyze configurations of subpatterns faster. Encoding of patterns at one level, perhaps letters, then serve as input to the recognition of higher-level subpatterns such as letter clusters. Therefore when reading, good readers may be able to encode more letters per single fixation with more certainty than poor readers.

Jackson (1980) has examined whether the visual memory-access speed advantage is dependent on familiarity. Adult subjects were asked to respond "same" or "different" on the basis of the physical identity of unfamiliar character pairs. There was no difference in reaction time or in general visual-processing speed. Subjects then had to learn a nonsense name with another set of unfamiliar characters. Both groups took an equal number of learning trials to reach criterion for accuracy yet better readers had faster reaction times in deciding whether two characters had the same name over two days of practice. Similar results were obtained for category matching, letter-name matching, and word matching whereas visual comparison of nonmeaningful patterns of dots without a verbal code did not produce differences between groups. The results suggest good readers are not more efficient in naming or matching tasks because of better visual comparison processes or general response time. Normal readers are faster at accessing a verbal code that is associated with and used to identify a visual stimulus.
The poor reader group did not improve in speed beyond the twenty-fourth trial. Perhaps practice in reading words in context will show greater increases in speed for the disabled reader who tends to rely on context more than the normal reader. What is still needed is a device which could maintain continuous voice activation and monitor time-per-word in this type of condition. The results of this study point to serious difficulties in identifying a method of word instruction that would yield similar vocalization latencies for the normal and poor reader.
References


Spring, C. Automaticity of word recognition under phonics and whole-word instruction. *Journal of Educational Psychology*, 1978, 70, 445-450.


**Appendix 1**

**Example Of One Individualized Word List Presented To A Subject**

<table>
<thead>
<tr>
<th>Target List</th>
<th>Visual Distractors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sight Words</strong></td>
<td></td>
</tr>
<tr>
<td>nature</td>
<td>nature, niture, natune</td>
</tr>
<tr>
<td>result</td>
<td>result, resilt, resast</td>
</tr>
<tr>
<td>belief</td>
<td>belief, barief, betief</td>
</tr>
<tr>
<td>business</td>
<td>business, business, bosiness</td>
</tr>
<tr>
<td>precious</td>
<td>pracious, precoous, pricous</td>
</tr>
<tr>
<td>advise</td>
<td>advise, advose, adsise</td>
</tr>
<tr>
<td>surprise</td>
<td>surprise, surgrise, surpese</td>
</tr>
<tr>
<td>anxious</td>
<td>anxuous, amxious, arxious</td>
</tr>
</tbody>
</table>

| **Phonics Words** | | |
| border | barder, borber, bonder |
| puppet | puppet, pippet, puppat |
| pilgrim | pilgram, pitgrim, pulgrim |
| focus | ficus, forus, fosus |
| motel | motol, metel, molel |
| secret | secrot, sacret, sesret |
| invent | invunt, invent, invent |
| spirit | spirat, sqirit, spisit |