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THERE ARE TWO KINDS OF POOR READER

By

© JOHN OTTO MITTERER

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Abstract

This thesis undertakes an analysis of current theories of fluent reading in Section 1. This analysis leads to the recognition of fluent readers as flexible. They can use both recoding and whole-word single word identification skills as required (LaBerge and Samuels, 1974) as well as use higher-order (top-down) semantic and syntactic knowledge in interaction with word identification (bottom-up) skills (Rumelhart, 1976).

In Section 2, theories of why some children have difficulty learning to read are considered with respect to the conclusions drawn in Section I. The tentative conclusion here is that poor readers do not lack the flexibility required to use higher-order skills in contrast with lower-order skills but that poor readers do lack the flexibility to use both word identification skills flexibly as the situation requires. That is, poor readers are characterized as inflexible in their over reliance on one or the other single word identification skill. This leads to the two major predictions of the current thesis. First, it is predicted that poor readers can be divided into two groups, whole-word poor readers and recoding poor readers respectively. This is demonstrated in Study 1 of the current thesis through an examination of the pattern of correct and incorrect responses to word lists in both the reading and spelling of poor readers in grade 3. The outcome of Study 1 is two groups of poor readers who rely on one or the other word identification skill. Experiments 1 and 2 demonstrate that the recoding poor readers are more

sensitive to sound-based properties of words than whole-word poor readers although Experiment 3 shows that this is true only for the purpose of lexical access, not for the purpose of promoting efficient use of S.T.M. Experiments 4 and 5 demonstrate that whole-word poor readers rely more heavily on the overall visual appearance of words than recoding poor readers.

Second, it is predicted that poor readers should show no strong deficit in the use of higher-order information to aid in word identification. Studies 2 and 3 demonstrate that both groups of poor readers can use context to aid in word identification. Study 2 demonstrates this for a simple category context and Study 3 demonstrates this for text. The results of Study 2 and 3 also show that contextual information overshadows the information of single word identification skills. That is, clear differences in skill preferences between the two types of poor reader when random word lists are read disappear when contextually constrained situations are used. This leads to the argument that contextually constrained "natural" reading situations may not be optimal for the investigation of reading deficits.

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Section One

In this section, some theoretical accounts of the reading process will be considered in order to establish the context within which the theoretical and empirical work of this thesis was undertaken. Continuing research on reading has fostered a growing awareness of the complexity of the reading process and of the fluent reader. In response to this awareness, recent theorizing explicitly pictures the fluent reader as a flexible information processor in command of an array of sub-skills which may be employed singly or in concert as the situation requires (e.g. Rumelhart, 1976; LaBerge and Samuels, 1974). A comprehensive discussion of all the sub-skills identified to date and their mode of interaction will not be undertaken. Rather, two main themes will be explored: the accessing of word meaning and the role of context in word identification. Both themes provide an illustration of the idea of flexibility.

The accessing of word meaning

Traditionally, two different skills for accessing word meaning have been considered: the recoding skill and the whole-word skill. The recoding skill is defined as follows: as reading goes on, letters are identified one-by-one in a left-to-right scan. Each letter (or spelling unit, e.g. 'CH') is sounded out and the resulting phonetic representations of words cue their meaning. Meanings of words are then combined to yield text comprehension. The whole-word skill is here defined as an identification of each word as a unit or whole pattern.

This visual pattern directly cues word meaning. Again, meanings of words are then combined to yield text comprehension. Two major differences between these skills can be identified(1):

(a) the recoding skill involves a sound-based code; the whole-word skill does not.

(b) The recoding skill involves a processing of individual letters; the whole-word skill does not.

Two further comments must be made. First, the skills as currently defined are too rigid. In all likelihood, both skills are applied some times to some words. That is, we should really speak of a reader as using both skills, perhaps relying most heavily on one. In what follows, "the recoding skill is used" will be taken to mean "the recoding skill is applied most of the time to most of the words." Second, the two skills as currently defined represent no more than points on a continuum extending from small-sized units to large sized units. For example, whole phrases might directly cue meaning. This possibility is not out of the question for commonly occurring word combinations such as people's names or common phrases such as "Merry Christmas" or "sincerely yours." Similarly, syllables, which are larger than letters but often smaller than words may be coded. A useful distinction on this continuum is that of sub-morphemic vs morphemic units. Presumably, sub-morphemic units such as letters or syllables <u>cannot</u> be associated directly with meaning (by definition) and are for this reason recoded. In contrast, morphemic units such as words and phrases (and some syllables) presumably <u>can</u> be associated directly with meaning. Henceforth, the whole-word skill will refer to a skill using a minimum of a morphemic unit and the recoding skill will refer to sub-morphemic units. Such a softening of the distinction is consistent with the findings of Glusko (1979).

The recoding skill has been assumed by many to describe the word identification of at least beginning readers. For example, Mathews (1966) discusses a very common form of teaching reading which can be traced back to the ancient Greeks; this instructional method seems to rest upon the assumption that reading is carried out by a recoding skill. Children were taught letter sounds first, then how to blend them into syllables and then words. Following recent usage (e.g. Chall, 1957) this teaching method will be labelled the phonics method.

A current example of a detailed interpretation of the recoding skill is provided by Gough (1972) as part of an information-processing model. This model is admirable in that it allows Gough to integrate a large set of data into a very detailed account. The present concern with this model is not with its details but rather, it is presented to establish that the phonic skill can be embodied in a model capable of organizing a large body of data: that is, it is not a straw man. Gough's model is schematized in Figure 1.

The current discussion of this model will ignore Gough's excellent treatment of temporal relationships and will concentrate simply on the directions of information flow. Information in the form of a light pattern striking the retina forms the input into the VISUAL SYSTEM. It has been hypothesized that the first processing step involves the detection of distinctive features available to the system in any given eye fixation (Gibson, Osser, Schiff & Smith, 1963). In

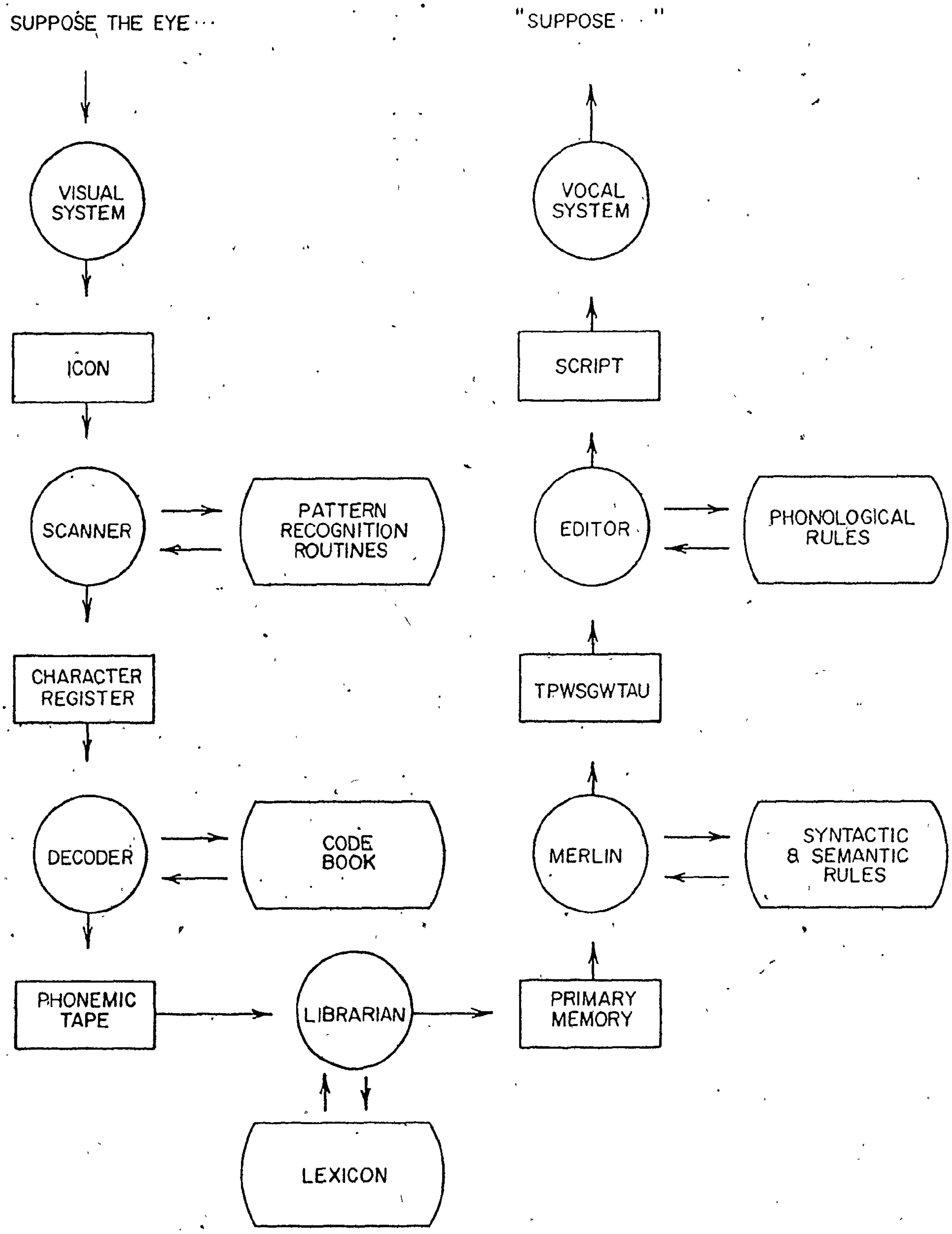


Figure 1 · A model of reading, from Gough (1972)

Gough's terms, the result of VISUAL SYSTEM processing is an ICON, a visual image containing bars, slits, edges, curves, angles and breaks(2). The ICON forms an input to a SCANNER which uses a set of PATTERN RECOGNITION ROUTINES in order to identify letters in serial order from left to right, with the resulting letter representation being stored in the CHARACTER REGISTER. The appropriate sound value for each character in the CHARACTER REGISTER is assigned by the DECODER using assignment rules stored in the CODE BOOK. The resulting phonemic representation is stored on the PHONEMIC TAPE. This sound-based representation forms the input to a LIBRARIAN which assigns meaning to word-units by searching for sound-meaning relations stored in the LEXICON. Word meanings are held in PRIMARY MEMORY while the poorly understood process of text comprehension, here labelled MERLIN, uses a set of SYNTACTIC & SEMANTIC RULES to yield sentence comprehension. Comprehended sentences are then held in TPWSGWTAU (the place where sentences go when they are understood) for subsequent processing - in Figure 1, for output in oral reading.

The question of whether reading must be characterized as being carried out by a recoding skill rather than a whole-word skill has generated much debate. (A similar state of affairs characterizes the question of whether reading should be taught using a whole-word or a phonics method; Chall (1957), was able to chronicle the question and aptly entitled her book The Great Debate.) What follows is a brief survey of some of the arguments which have been marshalled on one side or the other. It should be pointed out that these arguments focus on the question of whether recoding to sound is necessary for word-identification and generally ignore the question of whether morphemic or sub-morphemic units are processed.

An argument which has carried much force is one which asserts that the reader brings to the task of learning to read an already well-developed ability to process spoken language. This being true, it seems most economical to recode visual language input to sound as early as possible in the processing sequence, thus allowing the remaining processing to be carried out just as if the input had been auditory. On this account, the reader literally reads subvocally to himself and in the process of listening, then understands. All that need be learned by the beginning reader is a simple set of associations between letters and the sounds which they stand for in order to allow recoding to sound conveniently and early on in processing. In Gough's terms, the beginning reader already incorporates a LIBRARIAN, a MERLIN and an EDITOR for dealing with spoken language. Also, the beginning reader has a VISUAL SYSTEM and a SCANNER. All that is required is the acquisition of PATTERN RECOGNITION ROUTINES for letters and a DECODER. In contrast to this, any skill which does not allow for recoding, such as the whole-word skill, would require the development of much more sophisticated and redundant processing. Again, in Gough's terms, a parallel set of LIBRARIAN, MERLIN and EDITOR would need to be developed to process visual information.

In order to appreciate the cognitive economy which such a proposal seems to imply, consider Gough's LEXICON. Every beginning reader presumably already has a lexicon containing thousands of entries; that is, the average beginning reader already has a substantial comprehension vocabulary. The problem is that these entries contain a sound-based representation and the retrieval mechanism or LIBRARIAN presumably can access lexical entries through that representation. The options for the beginning reader seem to be either to recode to sound before lexical access or to add a visual, whole-word orthographic representation to each of the lexical entries as well as constructing a new retrieval mechanism to make use of them. Incidentally, the same choice seems to be faced by the fluent reader who may have a LEXICON with a hundred-thousand entries. Thus, the learning of a few associations between letters and sounds seems by far the most economical way to begin reading and perhaps even to read fluently.

This cognitive economy argument, supporting as it does the recoding skill against the whole-word skill, can be undercut. Smith (1973, Chapt. 7) argues that simple correspondences between spellings and sounds at the level of single letters to single sounds are far too complex and unreliable to be used as a tool for identifying words. Obviously, such simple correspondences do not get very far for the simple reason that 26 letters would have to map onto about 46 phonemes, so that some letters stand for more than one phoneme and some phonemes are represented by more than one letter. In addition, some phonemes are represented by letter clusters - th, ch, ou, ue, etc. Venezky (1967) estimated (for a corpus of 20,000 words), that there are 52 "major spelling units" in English. Berdiansky, Cronnel and Koehler (1969) isolated 69 such units. For a 6,000 word corpus of one and two syllable words in the comprehension vocabularies of children aged six to nine, 211 distinct correspondences between spelling and sound occurred. Of these, 79 were associated with the six primary vowels (a, e, i, o, u, y) alone. Smith (1973) argues that the number of correspondence rules involved and the problem of deciding when a particular rule apples argues against a strict reliance on the recoding skill in reading as well as against a strict reliance on phonics as the only method of reading instruction. Recoding from syllables to sound is also not as economical as one might at first suspect since there are several thousand syllables in English.

A second argument which has in the past carried much force concerns the reading of unfamiliar words. Words which are known to the reader but simply have never yet been encountered in printed form are supposed to pose no particular problem for a recoding skill since a sound-based representation can still be derived and used to access the lexical entry. In contrast, continues this argument, the whole-word reader can read only previously experienced words, those for which an association between a visual pattern and its meaning has already been established. Each unfamiliar word must be learned individually. Again the burden involved in this learning is held to be onerous.

Recent evidence has called into question this argument. The major force of the argument is carried by the claim that a whole-word skill cannot deal with unfamiliar words, but recently, Gulshko and Rumelhart (1977) provided evidence that readers can sometimes read words by a partial analogy to other words. For example, by the recoding skill, the non-word 'FOME' should receive a pronunciation rhyming with 'DOME'. Different responses to 'FOME' rhyming with and generated by apparent partial analogy to 'COME' also occur. This evidence opens up the appealing possibility that a reader relying on a whole-word skill can handle unfamiliar words by partial analogy to already learned words.

Several paradigms have been applied to the question of recoding in an attempt to provide clear evidence. The use of EMG recordings obtained from the larynx during reading suggests that some type of recoding is occurring. Edfeldt (1960) showed that almost all readers show subvocalization with poor readers showing more subvocalization than good readers. Also more activity was found to occur with difficult text. Hardyck and Petrinovich (1970) used feedback procedures to eliminate this subvocalization and found that this lowered comprehension although only on difficult material. Conrad (1972), however, points out that while subvocal articulation clearly does occur during reading, it is not really clear whether it is necessary or whether it merely accompanies silent reading (i.e., is epiphenomenal to silent reading).

Speculation about reading speed has been used to support both sides on the recoding issue. On the one hand stand those who find readers reading in excess of 500 words per minute (w.p.m.) without loss of comprehension (e.g. McLaughlin, 1969). Such a finding suggests that a whole-word skill is being used by such readers since speech occurs only rarely at speeds above 250-300 w.p.m.. On the assumption that recoding to speech sounds during reading is similarly limited to 250-300 w.p.m., it follows that some other skill (presumably a whole-word skill) must be used when reading 500 w.p.m.. Interestingly enough, it can also be argued that most readers in fact read at very nearly 250-300 w.p.m., suggesting that they may be recoding.

Another situation which yields relevant results is the STM paradigm. Conrad (1962) has shown that when consonants are visually presented for immediate recall, errors are based on articulatory similarity rather than visual similarity. Thus, 'D' is confused more often with 'T' than with 'O'. The argument is that visually presented material is recoded in order to promote better retention in STM. In another form of this type of experiment, Conrad (1971) presented lists of pictures for immediate recall. Some lists consisted of pictures whose names where phonologically similar (e.g cat, rat, bat, hat, etc.), for others, the names were not (e.g. fish, girl, bus, train, etc.). The finding of interest was that recall was poorer for the phonologically similar set. No such difference would be expected if pictures from both sets were only coded visually. The inference was that pictures must have been named and the names subsequently recalled. This finding is particularly interesting since an insistence on recoding is here <u>hurting</u> performance on the phonologically similar set. Thus, it appears that such recoding will occur in spite of cost, suggesting that it is difficult to avoid recoding.

The reading of congenitally and profound deaf readers has been taken as relevant to this question (Conrad, 1972). It seems reasonable that such readers would not use a sound-based code, instead relying exclusively on a visual code. In fact, such readers can learn to read, suggesting that the recoding skill is not necessary for successful reading. On the other hand, it must be noted that the reading fluency of deaf readers rarely approaches that of normal readers. This may be taken to suggest that a pure whole-word skill is not in itself sufficient for fluency.

Some empirical work with such children is very suggestive. Olsson and Furth (1966) found that deaf children have poor memory for digits when compared with normal children, but when shapes which are not easily named are used, deaf and normal children show equivalent memory. Furthermore, normal children show better memory for digits than shapes, while deaf children show a substantially reduced difference. The inference one is tempted to draw is that for deaf children, digits are just another visual pattern while naming or recoding of digits underlies their better retention in normal children.

It has recently been shown, using a lexical decision task, that it takes longer to reject a non-word if that non-word sounds like a real word (e.g., 'BRUME') than if it does not (e.g. 'BRUEL') (Rubenstein, Lewis & Rubenstein; 1971). This wouldn't be expected unless some recoding were occurring. On the other hand, Baron (1973) has shown that it takes no longer to decide that a phrase is nonsensical when that phrase sounds right (e.g. 'MY KNEW CAR') than when it doesn't (e.g. 'MY NO CAR').

This question of recoding has been clarified considerably by the work of Kleiman (1975). He distinguishes among three hypotheses. First, his "non-speech recoding hypothesis" is similar to the whole-word skill in proposing that reading occurs without recoding. The issue of recoding is clarified by the second and third hypotheses. The second is the "lexical access hypothesis" which is similar to the recoding skill in asserting that recoding directly precedes and mediates lexical access. The third hypothesis is the "working memory hypothesis." The claim here is that lexical access can occur directly from visual input and that speech recoding is required afterwards in order to maintain lexical items more efficiently for subsequent recall or for comprehension to occur. On this view, a speech-based code is most easily maintained in working memory. Since several lexical items must be held for sentence comprehension to occur, memory efficiency is important, and recoding provides a method for increasing efficiency.

In order to distinguish among the three hypotheses, Kleiman carried out three experiments which will be discussed in detail. The basic component of all these experiments was the use of decisions about strings of words with and without a concurrent shadowing task. The shadowing task, one of repeating digits has been shown to disrupt recoding to speech (Kroll, Parks, Parkinson, Bieber & Johnson, 1970). Thus, the degree to which concurrent shadowing interferes with some other decision can be used as an indicator of the importance of a speech-based code in that decision. A small amount of interference would be expected for a decision not requiring recoding because of general distraction and a larger amount of interference resulting both from general distraction and the specific disruption of recoding would be expected for decisions requiring recoding.

In his Experiment 1, Kleiman determined the effects of shadowing on three decisions about pairs of words;

1) A graphemic decision - do these words have similar spellings after the first letter? e.g. 'HEARD - BEARD' required a yes response,

'GRACE - PRICE' required a no response.

2) A phonemic decision - do these words sound alike after the first phoneme; i.e. do they rhyme? e.g. 'TICKLE - PICKLE' required a yes response, 'LEMON - DEMON' required a no response.

3) A synonymy decision - do these words have similar meanings? e.g. 'MOURN - GRIEVE' required a yes response, 'BRAVERY - QUANTITY' required a no response.

Kleiman found that concurrent vocalization interfered more with the phonemic decision than with the graphemic decision, presumably due to the disruption of the recoding required for the phonemic decision. The important finding was that concurrent vocalization interfered with the synonomy decision only as much as with the graphemic decision. This strongly suggests that recoding was not necessary in order to access the lexical information required for the synonymy decision.

In Experiment 2, Kleiman found no evidence that speech recoding plays a role in the graphemic decision, thus strengthening his arguments. He did this by contrasting two kinds of stimulus pairs, e.g. 'COUCH - TOUCH' vs. 'BLAME - FLAME'. If recoding played a role in the graphemic decision, one would expect rhyming pairs to be judged more quickly. More importantly, concurrent vocalization should interfere more with decisions about rhyming pairs. Briefly, the results showed no such effects, providing good evidence that speech recoding need play no substantial role in the graphemic decision.

The third experiment was a conceptual replication of the first with the addition of a fourth type of decision - an acceptability decision: do the five words in written order form a semantically acceptable sentence? For example, 'NOISY PARTIES DISTURB SLEEPING NEIGHBORS' required a yes response, 'PIZZAS HAVE BEEN EATING JERRY' required a no response. The results for the other three decisions replicated Experiment 1, again providing evidence against the use of recoding for lexical access. The acceptability decision, however, was interfered with as much as the phonemic decision, suggesting that recoding was employed.

Kleiman concluded, then, that speech recoding is not necessary for lexical access but is useful for holding items while semantic integration takes place. That is, he argued in favor of the working memory hypothesis. This point of view allows an integration of some of the previously mentioned arguments and data. Following Conrad (1971), and Kleiman (1975), it will here be assumed that most of the previously cited evidence for speech recoding (e.g. EMG recordings, STM studies) can be most easily interpreted as reflecting recoding whose purpose is not to effect lexical access, but rather to facilitate the holding of more than one item in working memory for some further purpose such as comprehension or recall. The only finding which is not immediately assimilated to this hypothesis is that of Rubenstein et al. (1971). In their work, words were dealt with one at a time and yet evidence for recoding was obtained. It is likely that the lexical decision task, containing as it does a high proportion of non-words which are quite unfamiliar, induces a general recoding set in readers who would not normally depend so exclusively on this skill.

Interestingly, the general conclusion that recoding is not necessary for reading, and may play a role not in lexical access but rather in maintaining retrieved items in S.T.M. integrates well with arguments of linguists who have been dealing with the seemingly poor fit between spoken and written English. Linguists such as Chomsky and Halle (1968) and C. Chomsky (1973) have argued that while English orthography is irregular and a relatively poor method of representing the spoken language, it does not necessarily follow that it is therefore a poor system of representation otherwise. Chomsky and Halle (1968) suggest that conventional spelling corresponds more closely to an underlying abstract level of representation than it does to the surface phonetic form that words assume when spoken. The argument is as follows: words are represented in the internal lexicon. This is the "lexical spelling" (C. Chomsky, 1973) or morphophonemic representation. For a word pair like n<u>a</u>tion vs n<u>a</u>tional, the lexical spelling would be similar in order to preserve the clear semantic similarity between the words. If the lexical spelling, on the other hand, were made to conform to the phonemics of each word, then two different spellings (one for each pronunciation of the "a") would be required in this phonemic lexicon. Rather than accept this, and the consequent obscuring of semantic similarity, Chomsky and Halle (1968) propose that the lexical spelling is submitted to a set of rules (phonology) which map to surface phonology. Thus, the input into the phonological component is a sentence in lexical spelling containing syntactic information. It remains for the phonological component to specify pronunciation which can only be done by taking into account the syntactic environment of the lexical items. As a general principle in deciding which rules go in the lexical spelling as opposed to the phonological component, Chomsky and Halle suggest that phonological variation need not be indicated in the lexical spelling when it is predicted by a general rule. So, for example, for nation vs national, this approach would represent both as having a long "a" in the lexicon, using phonological rules to shorten it in the context of certain suffixes.

This solution allows the underlying meaning of such pairs to remain unobscured (only one lexical spelling) while at the same time stressing the generality of the vowel pronunciation shift by making it a general phonological rule rather than obscuring their meaning by introducing two lexical entries for every word-pair that such vowel-shift is true of. To interpret briefly: If Chomsky and Halle (1968) are right, then such a representational network could permit reading to occur with more efficiency since spelling maps into meaning (the lexical spelling provides the route) without requiring processing of superficial and irrelevant phonetic detail. By this line of argument, reading would not be decoding to sound since this would involve going from graphemes to morphophonemes (lexical spelling) and then to sound. Notice that the last step is in no way necessary to access meaning and is in some sense an epiphenomenon of the word access process rather than a necessary step en route to meaning.

In accord with the above arguments, it is reasonable to reject Gough's model or any other model which does not admit the possibility of direct, visual access to the lexicon. A model which remedies this shortcoming was presented by La Berge and Samuels (1974) and is summarized in Figure 2.

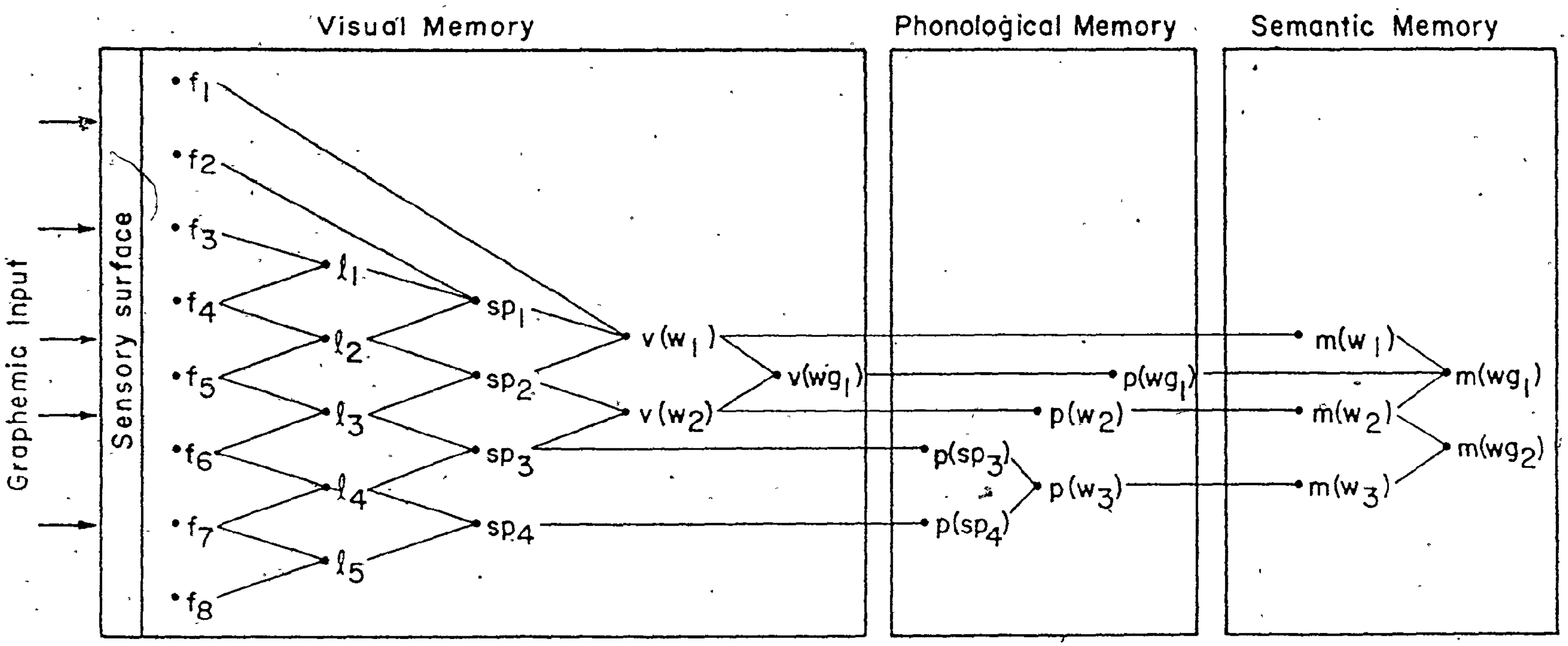


Figure 2. Reading in the LaBerge-Samuels' model. (After LaBerge and Samuels, 1974.)

Again, the work of LaBerge and Samuels (1974) is devoted not only to a specification of information flow but also to other problems, most notably that of automaticity. We will here ignore this to focus on directions of information flow. As can be seen from Figure 2, graphemic information is registered and is analysed by feature detectors which in turn feed into letter codes. Letter codes feed into spelling patterns and word codes. Most interesting for present purposes here is the possibility that some features (e.g. f_1 & f_2) can directly activate spelling patterns and word codes. That is, in this model, letters need not be completely identified prior to word identification. After this, two processing options are most important. The first has visual word codes directly activating meaning codes. This coupled with the earlier-mentioned possibility of feature information directly activating a visual word corresponds to the whole word skill as defined here. The second option has visual word codes and/or letter codes activating phonological codes which in turn activate meaning codes. Coupled with the earlier-mentioned possibility of feature information activating letter codes, this possibility corresponds to the recoding skill as defined here. What this model offers is an explicit attempt to describe flexibility of processing in reading, and hence the reasonable possibility that both skills are employed by normal readers. This may be true not only in the sense that some words are processed by one skill and some by the other, but also in the sense that both skills are applied to some words simultaneously. Operating in parallel, one skill will more quickly yield an acceptable response for some words, the other skill will work faster for other words.

Several studies are germane to the question of the flexibility of processing raised above. Consider first some work by Brooks (1976). Figure 3 outlines the nature of the stimuli used. Adult subjects were asked to learn associations between a small set of printed words and spoken responses. The words were presented in artificial alphabets, an example of which can be found in Figure 3. Four conditions were defined (see Figure 3). The first two will be labelled "discrete," which will be defined shortly. The first of these two was labelled discrete-orthographic. In this condition, each response can be derived from the stimulus by a one-to-one substitution of English sound for artificial letter. In the second condition, the alphabetic correspondence of the discrete-orthographic condition was disrupted by re-pairing stimuli and responses. In this condition, single artificial letters do not signal particular sound values reliably and hence the only way to deal with the learning task is to associate the whole visual pattern to the whole verbal response in a paired-associate fashion. This condition is the discrete paired-associate condition. In the remaining two conditions, one again was orthographic, one was paired associate. The difference between the first two and second two conditions is best understood with reference to Figure 3. Both discrete conditions follow normal English conventions with letters being arranged from left-to-right and one at a time. The other two conditions, the glyphic conditions, re-arrange the letters into a form which seems to enhance the overall visual pattern of each word. Thus

Figure 3

Sample Stimuli from Brooks (1976)

ALPHABET I	A	E	N	P	S	T
	⊔	)(	⊓	( )	III	—

STIMULI		RESPONSES			
DISCRETE	GLYPHIC	DISCRETE		GLYPHIC	
		ORTHOGRAPHIC	PAIRED-ASSOCIATE	ORTHOGRAPHIC	PAIRED-ASSOCIATE
LIST I	LIST GI	LIST I	LIST I	LIST GI	LIST GI
⊓ ⊔ ( ))(	— / ⊔ / III	NAPE	SEAT	TANS	PENT
⊓ ⊔ ( ) III	III / ⊓ /)(	NAPS	PANE	SANE	PEAT
III)(⊔ —	( ) /)(/ ⊔ / —	SEAT	NAPE	PEAT	SANE
( ) ⊔ III —	III / ( ) / III	PAST	SETS	SAPS	TAPE
( ) ⊔ ⊓)(	( ) /)(/ ⊓ / —	PANE	NAPS	PENT	TANS
III)(— III	— / ⊔ / ( ) /)(	SETS	PAST	TAPE	SAPS

we have two orthogonal factors defining four conditions: discrete orthographic, discrete paired-associate, glyphic orthographic, and glyphic paired-associate. Subjects in orthographic conditions were given practice in translating artificial letters into traditional English letter names. Following this, all subjects were given 300 trials. On each trial, a randomly ordered list of the six artificial words was read. The dependent variable was the time required to read each list. For present purposes the results seen in Figure 4 contain two important findings.

Focusing on the contrast between orthographic and paired-associates conditions, during early stages of practice it can be seen that the paired-associate conditions yielded faster reading times, but later in practice (at what looks to be asymptote) the orthographic groups showed significantly faster reading times. The implication of this is that adult readers at fluency are still able to make use of the sound properties of an alphabet. This result is surprising since the reading of adults at fluency is the place where theorists emphasizing the whole-word skill (e.g. Smith, 1973) have felt most secure in their assertions. Indeed, with only six associations to learn, one would expect the situation to be loaded in favor of a whole-word skill since the memory load is quite small.

Focusing on the contrast between discrete and glyphic conditions, the finding was that glyphic lists were read faster than discrete lists. Since the glyphic manipulation increases the configural properties of these stimuli (Brooks, 1976), it encourages holistic visual processing consistent with the whole-word skill. That

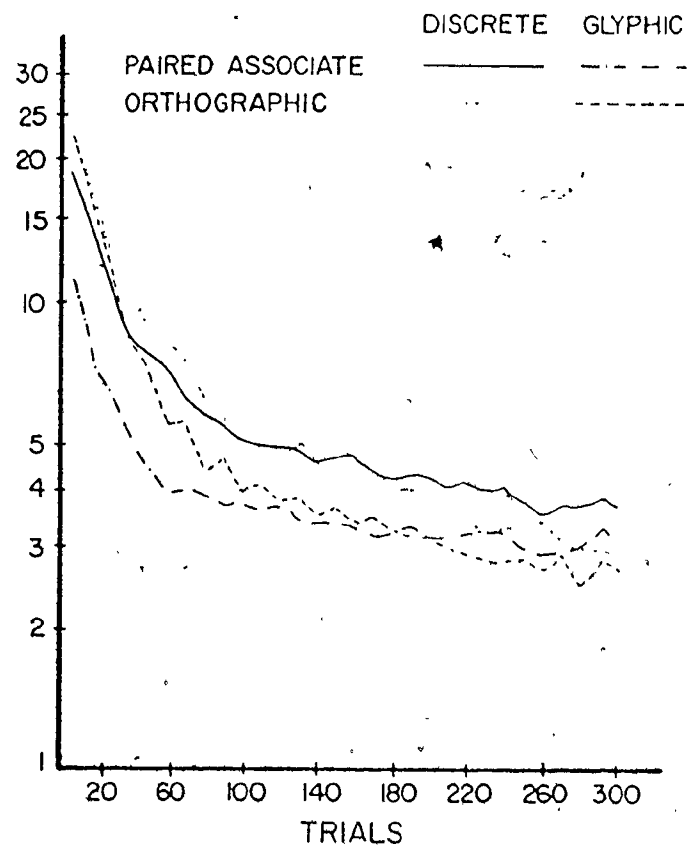


Figure 4. Results of the Glyphic-Discrete Experiment.

The effect of a functional alphabet is significant over the last 100 trials for both the discrete and the glyphic calligraphies. The effect of visual patterning is significant and does not significantly interact with the presence of a functional alphabet. From Brooks (1976) is, this experiment suggests that normal, fluent adult readers can and do use both skills in reading words at fluency.

Work by Baron and his colleagues (Baron & Hodge, 1978; Baron, 1979; Barron & Baron, 1977; Baron & Strawson, 1976) is also best interpreted as showing that readers use both skills but show preferences for one over another. Baron and Strawson (1976) isolated two different groups of adults which they labelled Chinese and Phonecians. Chinese were those relatively good at a whole-word skill but relatively poor at a recoding skill. Phonecians showed a reverse pattern. Subjects were selected for these groups based on two criteria: knowledge of orthographic rules and knowledge of whole-word patterns. Knowledge of orthographic rules was assessed by having prospective subjects decide whether or not nonsense words sound identical to real words. For example, 'CAIK' does and 'BURB' does not sound like a real English word. Knowledge of whole-word patterns was assessed by giving subjects 25 difficult words to spell. Following this, two alternative spellings were given for each word, e.g 'INSISTENT-INSISTANT'. In all cases, both possibilities lead to the same pronunciation, so orthographic knowledge does not allow them to be distinguished; rather, some specific whole-word knowledge is required. Subjects were assigned a score defined as the number of errors on the original spelling test minus the number of errors on the forced-choice test. This score is the improvement resulting from being able to see and use the correct spelling. Presumably, subjects who show high scores do so because of a feeling that the word "looks wrong," a feeling that cannot result from orthographic knowledge. Phonecians were defined as subjects showing high accuracy on the non-word task and a low score on the spelling task. Chinese were defined as showing a reverse pattern.

Two groups, defined as above, were asked to read lists of 10 words. Lists were composed either of orthographically regular words or irregular words written in lower case letters or in alternating upper case-lower case letters. A regular word is one which follows an accepted rule (from, e.g. Venezky, 1970). Take for example, the contrast 'BANE-BAN'. This follows a general rule that in the letter string consonant (C), vowel (V), consonant (C), E or CVCE, V is given a long pronunciation whereas in the letter string CVC, V is given a short pronunciation. Rules such as this are formulated by linguists to describe English orthography and also are used by teachers in early reading instruction. At any rate, by this "silent E" rule, 'BANE' and 'DOME' are regular but 'COME' and 'SOME' are irregular.

The results of interest from this experiment are twofold. First, if we look at the difference in time to pronounce regular words compared to irregular words, we find that Phonecians show a greater difference than Chinese. If Phonecians rely on a recoding skill, then words which are not correctly pronounceable by any rule must pose special difficulties relative to regular words. On the other hand, if Chinese rely on a whole-word skill, then the contrast between regular and exception words is irrelevant, being based on recoding but not visual considerations. As long as both regular and exception words are of equal word frequency, thus ensuring equal familiarity, then little difference in reading times should result. Second, words written by alternating upper-case and lower-case letters (e.g., CaSe or bReAk) slowed reading times relative to normal lower-case lists. However, Chinese were slowed more than Phonecians. Presumably alternating case destroyed word shape, a configural cue more important to the Chinese subjects' whole-word skill than to the Phonecian subjects' recoding skill.

A summary of what has been claimed up until this point is that the whole-word skill or the recoding skill alone is neither necessary for some reading to occur nor sufficient for fluent reading to occur. Even though fluent readers show preferences for one skill over another, both skills seem to be used. The claim is then that "Efficient reading is really a combination of two skills, both of which must be taught by any satisfactory method of teaching reading. They are, first, the ability to recognize accurately a large number of word and word groups as wholes, and second, the ability to work out the pronunciation of an unrecognized graphic configuration, in terms of its constituent phonograms and morphograms, until it is recognized as a unit of the spoken vocabulary" (Nelson, 1958).

This conclusion can be easily characterized as a type of flexibility. Fluent readers seem to be able to use one word identification skill or the other flexibly as the situation requires. This point will be elaborated in a section on theories of early reading disability and will play a central theoretical role in the development of this thesis.

Context and word identification

The second theme of this section is that of the role of context in word identification. Consider once again the model of Gough (1972) as presented in Figure 1; especially the linear, unidirectional nature of information flow. That is, features are identified, then letters, then letter sounds, then words, then sentence meaning and so on. Thus, the input is sequentially transformed from low level sensory information into ever "higher" or more abstract (with respect to the stimulus) encodings. Such an information flow is totally "bottom-up" (Rumelhart, 1976). A bottom-up system embodies a fundamental asymmetry in information flow since information processing is initiated by the sensory input and no higher level of processing can affect any lower level. This point applies equally well to LaBerge and Samuels' (1974) model outlined earlier.

Several writers have objected to any such purely "bottom-up" characterization of the reading process (Smith, 1973; Miller, 1973; Goodman, 1967). Smith (1973) argued that in fluent reading, only a small part of the information necessary for reading comprehension comes from the printed page. Furthermore, he suggested that only a small part of what is on the printed page is actually processed. Goodman (1967) elaborated on this point through a characterization of reading as a "psycholinguistic guessing game".

In order to appreciate this claim, a consideration of the cloze procedure (Taylor, 1953) is in order. In this procedure, segments of discourse are presented with words deleted (often as many as every fifth word). Subjects are asked to read the discourse segment and fill in the missing words. This is not impossible to do and results far above chance are quite normally obtained. The clear implication of this demonstration is that normal discourse is redundant and that this redundancy places constraints on what can fill in the blanks. As an example, the phrase "TWO PLUS TWO EQUALS ________" immediately allows one to fill in the blank appropriately. The psycholinguistic guessing game is simply a reading strategy in which redundancy is actively used in structuring what sensory information is taken in and to what depth it is processed. On this view, once a context has been established for some discourse segment, that context is actively used to generate hypotheses about what comes next, on a word by word level and also at a meaning or "gist" level. The role of incoming sensory information is restricted to use in testing generated hypotheses. In extreme cases, for example, an expert in some subject reading an introductory textbook on his subject may actually "read" a very small percentage of the words in the text, using his vast knowledge of the subject matter to guide a search for only a few key words or concepts. Most readers have experienced this kind of reading at some time or other and Goodman (1967) argued that this is what happens to some extent during almost all reading.

From this point of view, higher order information such as text theme, and the meaning of a sentence up to the current word play a strong role in determining how or even if that word is processed. Any system which allows for this possibility is said to allow "top-down" processing (Rumelhart, 1976).

At the level of word processing, a compelling empirical demonstration of the role of higher order processes is provided by the phenomenon of "priming". While this literature is extensive, a typical study from Mitterer (1977) will serve to make the point. In this experiment, the basic task facing the subject was to decide if a given letter string is or is not an English word. Immediately preceding each target string was a priming item which the subject was asked to read (but not otherwise respond to). Of primary interest here was the latency of the lexical decision to target words as a function of the semantic relationship between the prime and target item. The basic finding was that a given target word, e.g. 'DOG', could be correctly judged a word faster if a semantically related word, e.g. 'ANIMAL', preceded it than if an unrelated word, e.g. 'FURNITURE', preceded it. Furthermore, this facilitation by semantically related primes was found relative to a neutral prime, e.g. 'XXXX'.

From the point of view of a bottom-up model like that of Gough (1972), such a finding is difficult to explain. This is true since, as can be seen from Figure 1, the meaning of the target word 'DOG' does not become available until lexical access occurs. But once a meaning has been found, the lexical decision required by the experimenter can also be made. That is, the meaning of the target item cannot play any active role in speeding up the earlier stages of processing. On Gough's (1972) account, we should expect no difference in lexical decision time as a function of the prime since the prime can have its effect only in conjunction with the meaning of the target item which does not become available until lexical access and hence the lexical decision occurs. Facilitation of processing by semantically related primes has also been observed for recognition thresholds (Morton, 1964) and for vocalization latencies (e.g. Meyer, Schvaneveldt & Ruddy, 1975).

A similar demonstration of contextual effects on the processing of words comes from analyses of oral reading errors generated while reading text. The most common oral reading error is the substitution error which occurs when a stimulus word is misread as something else. Consider for a moment only those substitution errors which are themselves words. Weber (1968, 1970) has found, in first graders, that over 90% of these errors were grammatically consistent with the stimulus sentence to the point of the error. In a similar vein, Stevens and Rumelhart (1975) found, with adults, that nearly 80% of these errors were of the same syntactic class as the class most frequently predicted at that part in a cloze experiment. Also, Kolers (1970) found that 70% of these substitution errors made by adult readers were of the same part of speech as the stimulus word. Again, syntactic information that is supposedly available only very late in processing according to bottom-up models is influencing word processing, something supposedly occurring early in the processing flow.

While not central to the point to be made here, it can also be shown that letter perception depends on the environment in which the letter occurs. Thus, more letters can be apprehended in a fixed tachistoscopic exposure when a word is presented than when a string of unrelated letters is presented (Huey, 1968). Similarly, letter strings formed by either deleting or replacing some letters in a word are often misperceived as the original word (Pillsbury, 1897). Finally, it has been shown that a letter is more accurately perceived when it is part of a word than when it is part of a random letter string (Reicher, 1968; Wheeler, 1970).

In general, then, any model which stresses a linear bottom-up information flow will have difficulty in explaining the above types of findings. It appears necessary, then, to replace those models with a model capable of incorporating context effects as well as the basic data of reading. Two kinds of models have been proposed. Massaro, (1975) posited a kind of linear model in which processing stages overlap serially in time although not completely so. Rumelhart (1976) advanced a model in which all processing stages run simultaneously and constantly share information until comprehension occurs. The Rumelhart model is schematized in Figure 5. This model has been dubbed an interactive model because of this continual process of information sharing.

The operation of this model will be outlined in a very general way; Rumelhart (1976) should be consulted for greater detail. The heart of this model is the pattern-synthesizer. The best analogy to human cognitive psychology is "working memory" and a simplified analogy in computer processing is the "common store" of Fortran IV although both of these analogies are too passive.

Processing begins, as in the earlier discussed models, with feature extraction. As feature information is obtained it enters into the pattern synthesizer. Each of the knowledge sources is also operating simultaneously with the feature extraction system. Each knowledge source has access to any information in the pattern

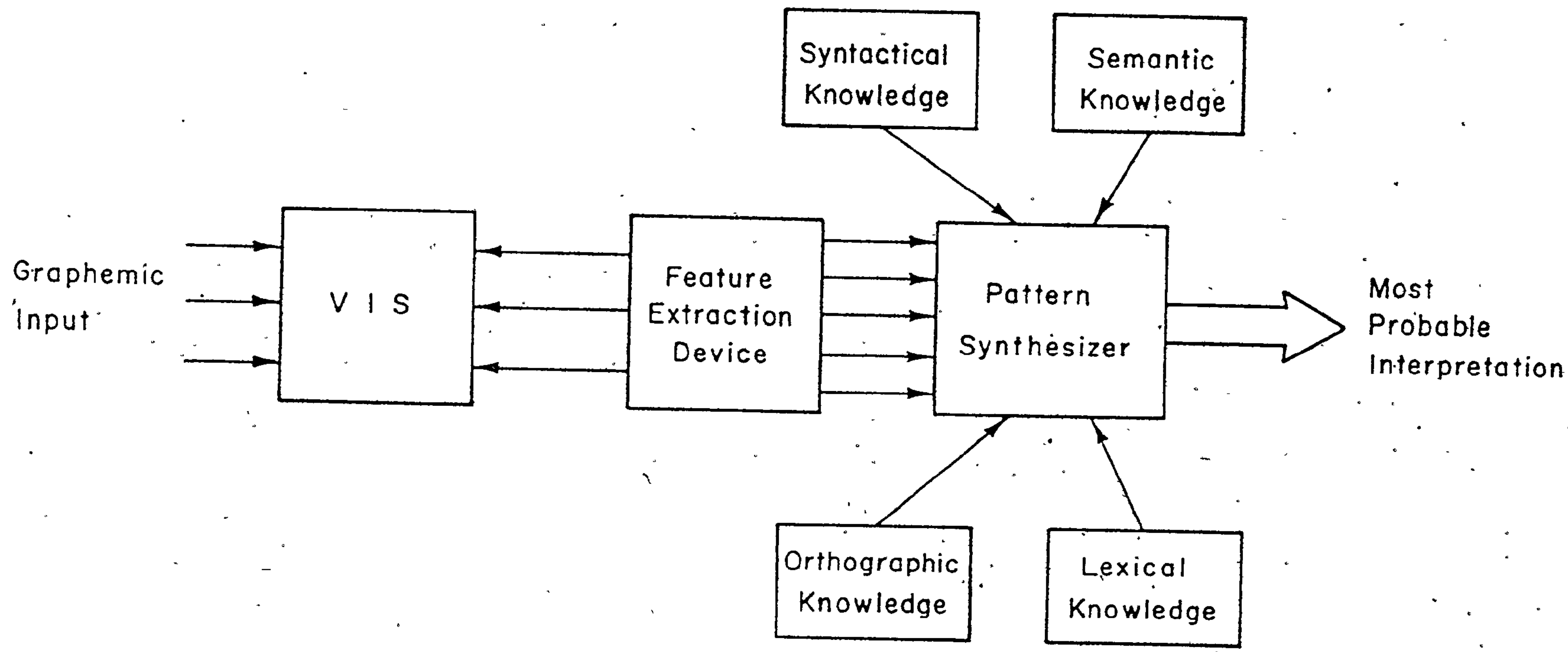


Figure 5. After Rumedhart (1976) A stage representation of an interactive model of reading.

synthesizer and is free to enter any additional information it can provide. This mutual interchange of hypotheses continues in real time until enough information is accumulated to produce a "most probable interpretation."

The interactive model above is again easily characterized in terms of flexibility. The contribution of each knowledge source to a final interpretation is seen as varying flexibly. With highly familiar material, the higher-order skills will contribute much; with unfamiliar material, lower-order skills will become more important. The fluent reader will be the reader who can allow one or the other type of strategy to come to the fore as the situation demands.

Conclusion

The motivation for advancing the idea of fluent reading as being carried out by flexibly utilizing a variety of skills is to provide a general framework capable of handling most of the data collected on this question. This is very explicitly why both LaBerge and Samuels (1974) and Rumelhart (1976) advanced their models and it seems reasonable that only such a general framework can provide a suitable starting point. This starting point will be used in the current thesis to develop an analysis of why some children experience difficulty in learning to read. To briefly anticipate, it will be suggested that such children lack some of the requisite flexibility and this claim will be supported with experimental evidence.

Finally, it should be noted that the theoretical scope offered by such notions is not obtained without cost. Specifically, as theoretical flexibility has increased, it has become more difficult to test these notions. Both the notions of Rumelhart (1976) and LaBerge and Samuels (1974) are in fact very difficult if not impossible to test. Therefore it is a subsidiary aim of this thesis to place some constraint on these notions via the study of individual differences.

Section Two

In this section then, the main question of the current thesis will be developed against the background of a picture of the fluent reader as being flexible. This main question is the question of why some children experience difficulty in learning to read. However, before this question is directly addressed, several subsidiary issues need to be cleared away.

The first of these issues is that of what to call these children having difficulty in learning to read. In the current work, the preferred term will be 'poor reader', as contrasted with 'good reader'. More commonly used older terms such as 'congenital word-blindness' and 'dyslexia' must be rejected. The first term is not appropriate because of the denotation that the locus of the problem is in the visual system, a presupposition at best. The second term has a reasonable denotative meaning but has been identified too often with the medical model and hence has implications of neurological deficits, again a presupposition.

The second issue is that of what kinds of performance constitute evidence that a child is a bad reader. Here, a list of 17 "principal errors" provided by Critchley (1964, p. 22-23) proves useful.

"1. Inability to pronounce an unfamiliar word with a tendency to guess wildly at its phonetic structure.

2. A failure to realize the likenesses and differences between words which are somewhat similar in spelling or in sound, e.g. 'PUG - BUD'; 'ON - NO'.

3. A failure to detect by ear, differences in the sound of words or letters.

4. Difficulty in keeping the correct place while reading.

5. Particular difficulty in switching accurately from the right hand extremity of one line of print to the beginning of the next line at the left.

6. Undue vocalizing of sounds while attempting to read silently.

7. Failure to read with sufficient understanding.

8. Incorrect pronunciation of vowels, e.g. 'BAG' for 'BIG'.

9. Incorrect pronunciation of consonants, e.g. 'BOLD' for 'BOLT'.

10. Reversals constitute a most important type of error, and may entail mirror-opposite letters (according to the typology employed). E.g. 'dip' vs 'big'. Or the whole word may be reversed, so that the child may read 'WAS' instead of 'SAW'. Or, again, short sequences of words may be read the wrong way, as in the case of 'DID HE' for 'HE DID'.

11. Phonemes may be interpolated incorrectly, as when the child reads 'RICK' instead of 'TICK'.

12. Phonemes may be dropped, especially out of consonantal clusters. Thus the child may read 'TICK' instead of 'TRICK'. Or whole syllables may be omitted, as when the child reads 'WALK' for 'WALKING'.

13. An error of a quite different type is seen whenever the child substitutes one word for another, e.g. 'WAS' for 'LIVED'. The word suggested may be one which is approximate in meaning, or one which is metonymous.

14. Words may be repeated in a perseverating fashion, e.g. 'THE CAT THE CAT'.

15. Words -- inappropriate or otherwise -- may be added, e.g. 'ONCE UPON A TIME THERE WAS' may be read instead of 'ONCE THERE WAS '.

16. One or more words may be omitted altogether, e.g. ' A DOG' instead of 'A FIERCE DOG'.

17. An omission of a different sort is seen in the phenomenon described in Monroe as a "refusal". Thus the child, attempting to read 'ONE OF THE MOST INTERESTING' may say 'ONE OF THE MOST' and stick completely over the word 'INTERESTING'."

The main feature of this list of principal errors is its thoroughness. If we exclude error 3 as not directly relevant and realize that errors 1, 2 and 7 merely restate the observation that readers doing these things can't read, we are left with a set of 13 types of error which poor readers are alleged to make. Very importantly, Critchley (p. 26) goes on to claim that "The numerous faults in reading which have been enumerated may occur at random in an individual case, being sometimes present, but at other times not". Thus in an extreme interpretation, we are left with an image of poor readers randomly generating a wide variety of errors, an image which will be discussed further shortly.

Of course, this notion must be elaborated further since even normal readers might be expected to show these kinds of errors some of the time. A criterion or set of criteria probably formulated in statistical terms will be required. Thus, only when performance drops below some normative reference point will the label "poor reader" be applicable.

The final subsidiary issue is that of a customary distinction between general deficits and deficits specific to reading. Only the latter are usually included in formulations of reading difficulty. Thus, several types of factors such as emotional disturbance, lack of formal instruction, gross perceptual deficits (e.g., partial blindness) and mental retardation can lead to poor reading performance. However, since in addition, most other types of performance are affected by these factors, no diagnosis of a reading-specific deficit is usually offered. In this vein, Carroll (1977) distinguishes between general cognitive abilities, general linguistic abilities and reading ability, implying that deficits in general cognitive or linguistic abilities need to be considered separately from reading ability. He goes on to suggest that many current reading tests may confound a diagnosis of reading problems, linguistic problems and even cognitive problems. The current solution to this problem is to use not only reading test scores, but also general intelligence test scores in selection of poor readers; that is, a child will be defined as a poor reader only if reading scores are some specified amount lower than would have been predicted based on general intelligence (both verbal and non-verbal) scores alone (e.g., Willows, 1974).

With all of the qualifications mentioned above taken into account, the important question to be asked is why such children are poor readers. The social relevance of this question is obvious as is its theoretical relevance. Three general classes of hypotheses have been advanced to answer this question.

1) Poor readers have a perceptual deficit. This is the classical explanation of reading problems as revealed by early labels for the problem (e.g. congenital word blindness). Evidence to be reviewed shortly will prove to be inconsistent with this type of hypothesis, and it will be rejected.

2) Poor readers have problems with higher-order contextual information. In section one it was shown that higher-order skills must play a role in fluent reading. This class of hypothesis asserts that the problem lies in poorly developed higher-order skills. Available evidence to be reviewed shortly again leads to rejection of this view.

3) Poor readers have a word identification problem. In section one it was shown that fluent readers can and do use two different word identification skills (whole-word and recoding) flexibly as the situation demands. Available evidence to be reviewed shortly supports the notion that this is where poor readers have their problem.

1) Do poor readers have a perceptual deficit?

Two forms of the perceptual-deficit hypothesis have been advanced. The first is that the perceptual process itself is disordered. On this account, the reason why some children are poor readers is that the printed page is literally not seen well. For example, reversal errors both at the letter level ('b' for 'd') and at the word level ('WAS' for 'SAW') have been supposed to occur because such children literally see the world backwards.

This is no longer a tenable theory for several reasons. First and foremost is the question of how such an account can explain the specific nature of the reading deficit. A peripheral perceptual problem should hinder the development of all skills based on that modality - here vision. Even basic skills like hand-eye coordination could be expected to suffer.

Second, strong evidence against this general notion has been presented by Vellutino and his colleagues (Vellutino, Steger, and Kandel, 1972; Vellutino, Smith, Steger and Kaman, 1975; Vellutino, Steger, DeSetto and Phillips, 1975). Take for example the work of Vellutino et al. (1972). Children were asked to view tachistoscopically presented designs, numbers, letters and words and then to reproduce them by drawing them from memory. Letter and word stimuli were selected in order to provide for the kind of orientational errors characteristically made, for example, the letters 'p' 'q' 'b' 'd'.

If poor readers have a perceptual deficit then their copying performance should be inferior to that of normals. However, no difference was found except for copying of five-letter words. Following this, the word series was shown again, and each child was asked to read and define each word. Incorrect pronunciations were corrected before definitions were elicited. Poor readers were found to be deficient in oral reading and spelling of the words but not in ability to define them. Also, poor readers' word pronunciations were characterized by a large number of errors (e.g. 'SUNG' for 'SNUG' and 'DIN' for 'BIN'), which have usually been interpreted as evidence for the perceptual-deficit notion. The fact that these poor readers were able to copy and define correctly for example 'SNUG' and yet misread it as 'SUNG' cannot be explained by that hypothesis and Vellutino et al. (1972) prefer instead the notion that these errors which obviously do occur in word recognition are a manifestation rather than a basic cause of reading disorder.

Also, Shankweiler and Liberman (1972) have examined these reversal errors in greater detail. They found that even in poor readers, letter and sequence reversals comprised only a small percentage of total errors, about 10-15%, and that test-retest reliability of these kinds of errors was less than for other kinds of errors. Interestingly, they found that fewer reversal errors occurred when letters were presented singly at short exposures. Under conditions of limited access to a letter stimulus, one might expect such errors to occur more frequently. It is also of interest to note that they found confusions were not symmetrical, for example, 'b' was confused with 'p' and 'd' but 'd' was confused only with 'b'. Even more interesting was the finding that letter reversals and letter-sequence reversals were uncorrelated! That is, a child who made letter-reversal errors was no more likely to make letter-sequence-reversal errors than one who did not make letter-reversal errors. These findings cannot be accounted for by the perceptual hypothesis.

The second form of the perceptual-deficit hypothesis suggests that poor readers may be deficient not in basic perceptual processing but in their ability to hold the results of that perceptual processing long enough for the completion of subsequent processing. Again, the same general criticism can be leveled in that such a notion cannot predict the specificity of the deficit and again good counter-evidence is available.

Also, some experimental evidence is not consistent with this class of hypothesis. Clifton-Everest (1974) presented normal and poor readers with an immediate-memory task involving recognition of meaningless line patterns presented for a time that was either greater than or less than the length of a single fixation in reading. The patterns were not easily coded into verbal form and hence had to be stored visually. No difference was found between groups of readers on this task. In an extension by Vellutino, Steger, DeSotto and Phillips (1975), Hebrew letters were presented visually for recognition immediately, 24 hours later, and six months later. Again, no differences between groups of normal and poor readers were found. Both studies concluded that visual-memory deficiencies are an unlikely source of reading difficulties. For the reasons given above, a perceptual-deficiency explanation of poor readers will not be considered further. In terms of Rumelhart's (1976) model, a problem with VIS and the feature-extraction device is not likely the source of most reading problems.

<u>2) Do poor readers have problems with higher-order contextual information?</u>

The second general hypothesis about the source of reading problems is that some inability to work with higher-order information is at the root of the problem. In terms of Rumelhart's (1976) model, syntactic and semantic knowledge sources are not operating effectively. In the terms of the present thesis, higher-order skills are defective. For example, Cromer (1970) found two groups of poor readers in college. One group had IQ scores and vocabulary scores equivalent to those of normal readers but relatively poor comprehension scores. The implication is that poor readers can be found who could read random word lists as well as normal readers but would have problems in text comprehension. In a similar vein, Smith (1973) has suggested that poor readers plod along reading one word at a time, not optimizing reading because they fail to use semantic and syntactic constraints effectively to reduce the amount of perceptual processing needed. In Goodman's (1967) terms, the poor reader is one who fails to engage in the psycholinguistic guessing game. In terms of Rumelhart's (1976) model, poor operation of syntactic and semantic knowledge sources will have two consequences. First, hypotheses from these knowledge sources will not contribute effectively to the pattern synthesizer and hence the burden of reading will fall primarily on bottom-up processes, thus slowing down reading. Second, text comprehension which depends on these knowledge sources will suffer.

While it certainly seems reasonable that some readers may in fact experience exactly this difficulty, evidence has been advanced which leads to a rejection of this type of account as describing more than a small proportion of poor readers. This evidence comes from two sources. First, there are the findings of a variety of researchers such as Perfetti and Lesgold (in press) which fail to support this idea. Second, there is the common finding that young poor readers can be distinguished from normal readers on the basis of difficulties in encoding single words. The first line of evidence will be examined in this section but the second line will be taken up in the next section.

The work of Perfetti and Lesgold (in press) is an example of work which has failed to uncover evidence of poor readers' inability to use higher-order information. They began with the assumption that discourse is structured at two levels. First, sentences are organized into units and subunits and second, overall text has a macro-structure (Van Dijk, 1974). If poor readers cannot process higher-order information as efficiently as normal readers, then differences in the use of these higher-order structural properties should be found.

A first experiment to be discussed centered around a sentence-structure variable - the clause boundary. For example, Aaronson and Scarborough (1977) used a continuous reading task in which a button is pressed for presentation of each subsequent word in a sentence. Slowest times were found at clause boundaries. Building on this sort of finding, Perfetti and Lesgold (in press) assumed that clause boundaries serve to regulate the encoding and analysis schedule of working memory. That is, the clause may be seen as a higher-order structure used to facilitate text encoding. The experiment they discussed came from Perfetti and Goldman (1976) and attempted to uncover differences between poor and normal readers in their ability to use this higher-order structure. The task used is that of Jarvella (1971) - the probe task. What Jarvella did was to present sentences and on occasion to interrupt and present a probe word which had occurred previously in the sentence. The subjects' task was, upon hearing the probe word, to produce the word immediately following the probe in the sentence. The finding of interest was that probe memory was not a simple function of how many words back in sentence (from the point of interruption) the probe had actually occurred. Instead, if the seventh word back from the interruption belonged to the currently heard sentence, it was as well recalled as the fourth word back. If it belonged to the previous sentence, it was much more poorly recalled. The conclusion was that the sentence boundary may serve as a signal for recoding information from the sentence, thus allowing the limited-capacity short-term memory to handle the next discourse segment. Perfetti and Goldman (1976) used the probe task to examine clause boundaries. Of interest here is the fact that poor and normal readers participated. The finding of importance is that while the poor and normal readers differed in overall level of memory, the clause boundary effect did not interact with reading level. That is, poor readers seemed just as proficient as good readers at using clause boundaries to facilitate processing.

Perfetti and Lesgold (in press) also examined the use of higher-order macro-structures. They cite, for example, some unpublished work of Berger (1975). The idea tested was that if higher-order organization is what normal readers can generate while poor readers can't, then memory differences should be predictable. Primarily, free recall of a passage should reveal larger differences than responses to literal questions. No such pattern of differences was found.

A second type of difference was also examined, paralleling a finding of DeGroot (1965) in a study of chess players. In that study, subjects were shown arrays of chess pieces on a chess board for a brief interval. Expert chess players showed better memory than beginners only if the arrays of chess pieces formed meaningfully possible chess configurations, not if pieces were randomly arranged. The conclusion drawn was that differences in raw memory ability did not distinguish experts from beginners. Rather, a knowledge of the overall structure of the game of chess allowed experts to assimilate meaningful chess configurations more effectively. Similarly, a manipulation of thematic structure was the core of this particular experiment from Berger (1975). The memory advantage of normal readers over poor readers did not diminish when discourse became less thematic, suggesting that skill in using higher-order organization was equivalent in the two groups, a result paralleling that of DeGroot (1965).

Perhaps the strongest evidence against the idea that normal readers are better than poor readers at using higher-order context while reading has been presented by Allington and Strange (1977) and by Kolers (1975). According to Goodman (1967), as reading fluency develops, reliance on contextual (higher-order) information increases and dependence on graphic (lower-order) information decreases. Allington and Strange (1977) tested a correlate of this position, namely that good readers should be less upset by graphemic changes and more able to use context to supply the correct word. On the other hand, poor readers should be less able to use context and should be more upset by graphemic changes. For example, if the sentence 'JUST

THEM AN OWL CAME DOWN' is presented, good readers should experience no difficulty in supplying 'THEN' as the semantically appropriate word (as opposed to 'THEM') in that sentence. In contrast, poor readers should bog down on the word 'THEM' and be less able to supply the correct one. Allington and Strange found that the semantically inappropriate word (in the example it was 'THEM') was in fact read 40% of the time for good readers and only 27% of the time for poor readers. While the difference was not significant, it must be noted that it was in the opposite direction to that predicted. In addition, the semantically appropriate word was supplied about 56% of the time for both groups. Thus, no difference in sensitivity to context was found.

As a final result, consider the findings of Kolers (1975). Sentences were read either in a normal or in an inverted orientation. On a subsequent test, the old sentences and an equal number of new sentences were presented. Half of the old sentences which had originally been read in normal orientation were subsequently tested in normal orientation, half in inverted orientation. Similarly, the half of the old sentences read in inverted orientation were tested half in inverted orientation and half in normal orientation. Children who were normal and poor readers answered two questions about each test sentences: 1) is it old or new? 2) if it is old, is it in the same or a different orientation as before? This procedure allows independent manipulation and subsequent testing of graphemic information (orientation) and higher-order information (meaning). The basic results were that readers did not differ in terms of old-new decisions and that normal good readers were more sensitive to graphemic information. The idea that normal readers use higher-order information and bad readers do not cannot explain these results since that notion predicts an advantage for normal readers for the meaning information and an advantage for poor readers for the graphemic information. Kolers concluded that the poor reader is impaired not at the semantic level but at the graphemic level.

To conclude, data from many sources fail to support the idea that differences between normal and poor readers can be accounted for in terms of a deficit in poor reader's use of higher-order information. When poor readers are placed in contexts where such information is available, they seem able to use it. If poor readers lack some flexibility in adapting their reading to different circumstances, this lack of flexibility is not to be found in use of higher-order information. To anticipate, children from the current work were also tested for their ability to use context (see Studies 2 and 3), and consonant with the above conclusions, no clear evidence for such a deficit was uncovered. For these reasons, a lack of flexibility in using higher-order context will not be considered further as a major source of individual differences in reading ability.

<u>3) Do poor readers have a word identification problem?</u>

The last major class of hypotheses concerning why poor readers are poor centers around the processes involved in deriving the meaning of a single word from its printed form. In terms of Rumelhart's (1976) model, the problem lies somewhere in the orthographic source and/or the lexical source.

Consider for example the thesis of Firth (1972). He used two reading tests as criterion tests to define reading ability (Schonnell R.I. and Neale). A wide range of predictor tests was used including a test of speech ability, vocabulary, a paired-associates learning task (to tap whole-word processes), a test of ability to identify words in context, a sentence memory test, a test of children's ability to produce the names of letters of the alphabet, an auditory blending task, an auditory analysis task, a speech discrimination task, a set of tests on visual perception and recognition and a test of ability to read nonsense words. (Details may be found in Firth, 1972, pp. 31-82). With IQ controlled, the finding was that skill in generating pronunciations to nonsense words accounted for most of the variance in reading achievement, both for six-year olds and eight-year olds. This finding suggests strongly that the ability to derive pronunciations for single 'words' is most critical in fluent reading.

Similarly, Shankweiler and Liberman (1972) have found high correlations ($\underline{r}$ = .70) between Gray Oral Reading test fluency scores and oral reading performance on word lists. Also found was a high negative correlation ($\underline{r}$ = -.68) between response latency and accuracy in both word lists and connected text. The conclusion drawn was that inaccuracy and slowness in reading of individual words contributes to poor performance on paragraphs.

Finally, to anticipate work of the current thesis, all poor readers investigated showed deficits in processing of single words. The overall implication of these data is that it will be difficult to find poor readers especially among children who do not show deficits on single word processing. It becomes parsimonious, then, to assume that difficulties in text comprehension arise because the individual words in that text are not processed adequately. It is easy to see how an inability to identify easily a large percentage of words in text will yield poor comprehension of that text. According to Perfetti and Lesgold (in press), even where words are being successfully identified, the time and effort required by the poor reader to do so is excessive, and this leads to comprehension difficulties.

The explanation of why this would be so begins with the conception of the reading process as one in which all of the sub-skills not only interact with each other but must share at least in part a limited-capacity mechanism. This notion has also been embodied in the reading model of LaBerge and Samuels (1974). On this view, when too much effort is required for single-word decoding, less processing capacity remains for higher-order processes. Thus for example, memory for the previously coded word(s) may suffer, memory for the preceding phrase may decrease and the child's ability to use context as a predictor of what is to come may diminish. This hypothetical account of the origin of poor reading was dubbed by Perfetti and Lesgold (in press) the "hysteresis hypothesis". Evidence for this point of view was provided by Perfetti and Hogaboam (1975) who looked at vocalization latencies for high-frequency words, low-frequency words, and pseudo-words. Even when vocabulary differences are controlled (for real words), good readers read faster, especially so on low-frequency words and pseudowords. To summarize to this point, an inability of poor readers to process single words and pseudowords persistently crops up in research studies. It is parsimonious to suggest that this inability underlies comprehension problems, especially when put together with the negative evidence presented on the context-use deficit hypothesis. Although, of course, it can still be argued that poor readers show both a single-word-identification problem and an inability to use higher-order information, there are currently no studies on young poor readers which are relevant to distinguishing between these two alternatives. Accordingly, the principle of parsimony will be upheld.

Assuming then, that the source of difficulties for poor readers is in single-word encoding, the question of exactly how the problem arises must be considered. While most theorists have explicitly accepted the distinction drawn earlier between the recoding skill and the whole-word skill, theoretical disagreements concerning the single-word problem do occur. As discussed in section one, available recent evidence suggests fluent readers use both whole-word and recoding skills flexibly. In contrast to this, several theories of why children have problems at single word identification work on the assumption that fluent reading requires predominantly only one or the other skill. This has led to strong theoretical claims about the source of poor readers' word identification problem.

Smith (1973, Chapters 6 & 7) argues, as does Goodman (1967), that the fluent reader relies only minimally on the recoding skill when engaged in reading text. Instead, a heavy reliance on context is coupled with increased reliance on the whole-word skill. On this account, poor readers are seen as "word-plodders" who use a phonic skill to sound out word after word, one word at a time. The energy involved in doing this leaves little or none for higher-order processing, resulting in poor comprehension. Thus poor readers are characterized as relying too heavily on a recoding skill while normal readers rely largely on a whole-word skill.

In contrast to these claims stand those of Rozin and Gleitman (Rozin and Gleitman, 1977; Gleitman and Rozin, 1977). Their basic argument is as follows: The preliterate child can process visually presented material, showing no problem in visual letter discrimination. Visual-to-auditory translation is no problem since preliterate children can learn to name pictures. Rozin, Poritsky and Sotsky (1971) found that American children with reading problems can easily learn to read English represented by Chinese characters. That is, no deficit in the whole-word skill can be found. Preliterate children can repeat acoustically presented minimal contrasts such as 'BAT' vs. 'PAT' correctly; therefore auditory perceptual skills are not likely a problem. Also, almost every kindergartner is said to be capable of understanding utterances far more complex than anything presented as reading material will be, suggesting that no higher-order processing deficits are at the root of the problem.

The problem, Rozin and Gleitman (1977) suggest, lies with the alphabetic principle. They claim that a conscious awareness of the phonological basis of alphabetic orthography is required to learn to use the recoding skill and that many children just beginning to read are not yet aware of phonemes. Since, generally, letters of the alphabet do correspond to phonemes, a failure to understand what a phoneme is will lead to difficulties in understanding what letters are for. In support of this notion, Savin (1972) argues that children who can't read at the end of grade 1 are also unable to analyse syllables (a more natural unit) into phonemes. They are insensitive to rhyme, and to see that two syllables rhyme, one must notice that they differ only in initial consonant sound or are otherwise identical. To do this, the syllable must be analyzed into shorter segments. In addition, Savin (1972) argues that these poor readers cannot understand that the words 'CAT' and 'COW' begin with the same sound or that 'CAT' ends in the sound 'AT' even though the syllabic segmentation of 'WINDOW' into 'WIN' and 'DOW' is possible. Finally, he suggests that these poor readers cannot learn Pig Latin. This "language" requires modification of English by shifting the initial consonant sound of each word to the end of the word and then adding the sound 'AY'. Thus, 'HOUSE' becomes 'OUSEHAY'. Again, all of these activities require an ability to segment syllables into smaller units. Savin (1972) suggests that most four-year olds also cannot do this and that non-readers at age six or seven have still not developed this capacity.

Relying upon the arguments just outlined, Rozin and Gleitman (1977) suggested that poor readers are poor readers precisely because they cannot analyze syllables into phonemes and as such cannot learn to associate those phoneme sounds with particular letters of the alphabet, consequently they experience reading problems. On this account, poor readers are those who cannot use a recoding skill and hence are forced to rely exclusively on a whole-word skill.

The final point of view, as suggested by the analysis in Section 1 and the one accepted in this thesis hold that both single word identification skills are necessary for fluent reading and bad readers lack one or the other skill. This point of view has been presented by Boder (1973) and by Baron, most notably Baron (1979). Boder (1973) worked with severely disadvantaged readers in their teens. These readers showed at least two very distinct types of errors particularly when spelling. Some of these poor readers when spelling and reading isolated words would make errors that were far from the correct pronunciation. These children could not read or spell nonsense words. It appears that these poor readers are deficient in the use of a recoding skill. A second group of poor readers misspelled and mispronounced words with irregular pronunciations. These poor readers seemed deficient in the use of the whole-word skill that is required to deal with these words. The article by Boder (1973) is written in a clinical fashion and hence can provide little more than stimulating ideas. However, Baron, (1979) has also shown that poor readers may show variability in dependence on these skills, being segmentable into groups relying on one or the other skill. He used poor readers from grade 4 and had them read lists of nonsense words, regular words and irregular words. His logic was that nonsense words (N) should be read by a recoding skill just as regular words (R) but that irregular words (I) should be read by the whole-word skill. Therefore, the correlation between N and R ($\underline{r}$(NR)) should be greater than $\underline{r}$(IR), since a single skill is used for both N and R words but different skills are used for I vs. R words. Using the number of words in each list pronounced correctly as the dependent variable, Baron found $\underline{r}$(NR) > $\underline{r}$(IR). This result can be interpreted to show that two different skills were used by these poor readers since if one strategy were used, $\underline{r}(NR) = \underline{r}(Ir)$. In an analysis of errors, Baron found two patterns. Some readers made sound preserving errors (e.g. 'PINT' could be pronounced as in 'TINT'), errors easily understood as stemming from the recoding skill, and others made wilder errors such as 'PAPER' for 'PAGE', an error more easily understood as stemming from the whole-word skill. Baron (1979) interpreted such errors as meaning-preserving errors.

To summarize, evidence is available that poor readers may rely on one or the other skill. Baron and Strawson (1976, p. 352) noted that "... the success of experiment 2 indicates that proficient readers do differ from one another in the extent to which they rely on the two different mechanisms. It seems likely that the differences in our sample may not be as extreme as the differences in the entire population of readers. It might thus be of interest to examine poorer readers with some of the techniques used here, possibly as a way of discovering deficits confined to one mechanism or the other".

Overall, several proposed explanations of reading difficulties were examined. Based on available evidence, reading difficulties are best explained as resulting from deficiencies in encoding single words. Three different hypotheses all consistent with such a deficit were advanced. One proposes that poor readers are deficient in the whole-word skill and rely too heavily on the recoding skill. Another proposes that poor readers are deficient in the recoding skill and rely too heavily on the whole-word skill. The third, and preferred hypothesis is derived from the work of Baron and Strawson (1976) and the theoretical arguments concerning processing flexibility advanced in section one. This hypothesis asserts that poor readers are not flexible, relying too heavily on one or the other skill. On this view, poor readers can be divided into two populations. One group of poor readers depends too heavily on the recoding skill and the other group depends too heavily on the whole-word skill. The experimental work which follows attempted to substantiate this claim. Additionally, flexibility in use of context to aid in word recognition was also investigated, with the assumption that no obvious deficit here could be uncovered.

To sum up, the available evidence coupled with recent theoretical work on fluent reading suggests that poor readers lack some of the required flexibility, not in terms of context use, but in terms of having available for use the two different word identification skills. The work which follows investigated these possibilities.

Study 1

Introduction

This study concerned itself with obtaining evidence bearing on the proposition that two relatively distinct types of poor reader can be found, namely whole-word poor readers and recoding poor readers. It was also deemed desirable for this attempt at diagnosis to be relatively simple in terms of conception and especially execution since it was hoped that a simple diagnostic tool suitable for applied use might ultimately be developed. In order to satisfy this constraint, children's verbal and written responses to visually presented words were studied. Simply put, children were asked to read and spell some words for subsequent analysis.

In order to generate predictions, a more precise account of how the recoding and whole-word skills achieve word identification is necessary. In the recoding skill, the primary job is that of assigning sound values to letters, based on a set of assignment rules. Memory for pronunciations of particular instances or examples does not play any role in this skill. The job of the reader who seeks to develop this skill is the job of inducing a set of assignment rules which lead to successful recoding. In contrast, in the whole-word skill, the primary job is that of collecting a large set of unique associations between printed words and responses. Memory for particular instances plays a large role in the skill.

If poor readers following relatively pure recoding and whole-word skills respectively are asked to read and spell orthographically regular and irregular words as well as nonwords, several predictions can be made:

1) Recoding poor readers, being very sensitive to orthographic regularity, should be more often correct on orthographically regular than on orthographically irregular words. This is so since, at best, an orthographically regular pronunciation would often be given an irregular word, leading to an error. For example, the orthographically regular word 'SWORE' may be pronounced correctly, but the irregular word 'SWORD' may be given the same 'SW' sound as in 'SWORE' - an error. In contrast, as long as the regular and irregular words were equivalent in terms of the likelihood that they would be encountered (i.e., word frequency), whole-word poor readers, not being sensitive to orthographic rules, should be no more often correct on regular than on irregular words. At a minimum, the difference between number of regular words correctly read and number of irregular words correctly read (REG-IRREG) should be larger for recoding poor readers than for whole-word poor readers. A comparable result has been obtained by Baron and Strawson (1976) with fluent adults in that, with response latency as the dependent measure, REG-IRREG is greater for Phoneclans (recoders) than for Chinese (whole-word readers).

2) The kinds of errors made in word reading should differentiate use of the two skills. A recoding poor reader should err primarily in using the wrong assignment rule in deriving a pronunciation. Thus 'PAGE' may be misread as rhyming with 'BAGGY'; in

this case, the 'A' is given a short rather than long pronunciation, the 'G' is given a hard rather than soft pronunciation and the 'E' is given a long rather than null pronunciation. This error might arise if the normal pronunciation rule for the silent 'E' were not applied. In this sample error, every letter is given a sound value, even though some are incorrect. Such errors will be referred to as "conservative errors" (CON). Notice that in conservative errors, no letter is given a null pronunciation, as for example in the pronunciation 'TAP' for the presented word 'TRAP' and no extraneous sounds are included, as for example 'BLOW' for the presented 'BOW'. Such errors, departing as they do from orthographic assignment rules will be labelled "liberal errors" (LIB). Errors generated by recoding poor readers should be predominantly conservative errors. In contrast, when whole-word poor readers are faced with an unfamiliar word, they can't sound it out and hence cannot generate conservative errors. What they could do is search their lexicon for similar items. When a sufficiently similar item is uncovered, it can be output as a guess. For example, the word 'GREED' may be misread as 'GREEN' since 'GREED' is unknown but is highly similar to 'GREEN' which is known. Notice here, that the error which is generated is liberal, not conservative. Therefore, if we define a difference score for the number of conservative errors minus the number of liberal errors (CON-LIB), then CON-LIB should be larger for recoding poor readers than for whole-word poor readers.

3) Some of the errors which these poor readers make will themselves be words. In fact, it seems quite likely that whole-word poor readers will generate incorrect words quite often. On the other

hand, recoding poor readers, generating conservative errors, should more often generate non-words, since changing single letter sounds conservatively for any word seems more likely to yield non-words. Thus, if we define a difference score as the number of non-word errors minus the number of word errors (NW-W), this score should be larger for recoding poor readers than for whole-word poor readers, for whom NW-W may be negative.

4) Considering the ability to read nonwords, if we tabulate the number of nonwords given regular pronunciations (REG-PRO), then REG-PRO should be larger for recoding poor readers, a straightforward prediction since non-words should be unfamiliar to whole-word poor readers.

5) A tabulation of errors in reading nonwords should reveal identical patterns as for words for both types of poor readers. Thus the difference score nonword errors minus word errors for these nonwords (NW-W NONWORD) should be larger for recoding poor readers.

6) A study by Boder (1973) found that in the spelling of poor readers, three types of error patterns could be found. The first two are identifiable as those generated by recoding poor readers and by whole-word poor readers respectively. Recoding poor readers were called Dyseidetic Dyslexics by Boder. Their spelling errors were closely related to the recoding skill and thus were phonetically based (For example, 'LAUGH' misspelled as 'LAF' and 'BIRD' misspelled as 'BURD'). Again, these errors are rightly conservative errors as earlier defined in that each sound in the word to be spelled is assigned a letter in the misspelling, albeit an incorrect letter.

Whole-word poor readers, whom Boder calls Dysphonetic Dyslexics, could not spell phonetically. According to Boder, if such a poor reader can re-visualize a familiar word then a correct spelling will result; if not, then bizarre misspellings including extraneous letters and omitted syllables occur. As examples, she offers the misspelling 'BEEVER' for 'BELIEVE' and 'REMBER' for 'REMEMBER'. These are extreme examples--and are certainly liberal errors. Although Boder's work is with much older children having severe problems, it seems reasonable that a similar difference might be found here. Thus, the prediction is that the difference score of conservative minus liberal errors for spelling (CON-LIB SP) should be larger for recoding poor readers than for whole-word poor readers.

7) Finally the difference score of the number of regular words correct minus the number of irregular words correct for spelling (REG-IRREG SP) should also be larger for recoding poor readers than for whole-word poor readers for the same reasons as in 1.

It is important to realize that in general no predictions about levels of absolute performance are possible since different factors should affect performance for children relying on recoding as opposed to whole-word skills. Orthographic regularity should be a potent variable for the recoding skill and word familiarity as indexed by word-frequency norms should be a potent variable for the whole-word skill. High frequency irregular words should be better for whole-word readers relative to recoding readers whereas low-frequency regular words should be better for recoding readers relative to whole-word readers. Thus in any actual set of words, absolute performance will be determined by the set of words used.

The most important prediction is that if the to-be-observed population of poor readers in fact contains poor readers relying heavily on one skill as opposed to the other, then each of the variables just defined should show reasonable variability and when an inter-correlation matrix for these variables is examined, all correlations should be high. Another way of expressing this is that in a factor analysis, a factor should emerge with which all of the variables mentioned above correlate highly. Such a factor would be tentatively labelled a recoding - whole-word factor.

If the population of poor readers is homogenous; (i.e., does not contain these two relatively distinct types of readers), then the variables defined should show smaller ranges and critically, an intercorrelation matrix should show low values. Alternately, a factor-analysis should find no evidence for a recoding - whole-word factor. Thus, evidence could be brought to bear on the earlier mentioned assumption of Critchley (1964) that the different types of reading errors are randomly distributed in the population of poor readers.

To this end, a group of poor readers was studied. All poor readers met a set of criteria which will be better specified shortly (poor reading performance, normal IQ). These readers were asked to read and spell regular and irregular words as well as to read non-words and several measures including the ones described above were tabulated. In addition, a set of good readers (good reading performance, normal IQ) was included for comparison purposes.

Method

Subject Selection

The work to be reported in the remainder of this thesis was carried out exclusively with grade-3 students. This grade level was chosen for two major reasons outlined below.

1) In the earlier grades 1 and 2, not as much variability in reading ability is found: the good and poor reader in grade 1 are not as disparate as the good and poor reader in grade 3. With reference to a reading test like the Gates-MacGinitie (1964), it is easy with grade-3 readers to find those reading at a grade 4.5 level and those reading at a grade 1.5 level. These scores are about 2.5 standard deviations apart and index large differences in reading ability as will be documented shortly. Further, scores of 1.5 reading level are scores suggesting that children with at least two years of formal reading instruction have scarcely benefitted from it at all. Such children seem to have reading problems and most school boards concur and will refer grade-3 children with such scores for remedial work. To sum up, by grade 3, the child with a reading problem is relatively easy to pick out, by virtue of reading behavior substantially different from that of his more accomplished peers and scarcely better than that of an average grade-1 reader.

2) It was deemed desirable to avoid studying higher grade levels for the following reason. It seemed that an important inflection point occurs in the development of reading proficiency. Before this point is reached, even normally progressing readers cannot

read well enough to read all of the words which they can speak. In this case, reading is not yet an effective mode of conceptual development. So, for example, a grade-3 child may have heard about astronauts and space-stations but still not be able to read a story containing those words. After this inflection point, however, reading skill has improved so that segments of conceptually unfamiliar material can be read and hence understood. Now, reading has become an instrument of conceptual development. Some pilot work showed that even relatively good grade-3 readers still made reading errors on words which were in their spoken vocabulary. This suggested that reading was not yet a skill developed well enough to contribute substantially to general intellectual development. This being true, good and poor reading groups who were equal in some measure of conceptual development could be studied with confidence that the conceptual development in the two groups had come about in substantially the same way (i.e., not by reading). This would not be as easy to achieve in later grades since for good readers, at least, reading proficiency would be contributing to conceptual development leading to a substantial correlation of reading ability with conceptual development. To rephrase, it was felt that as grade level increases, the correlation between reading ability and conceptual development (e.g. IQ) would increase. The higher the correlation, the more difficult it would be to obtain good and poor readers matched in IQ but sufficiently disparate in reading ability. To sum up, Grade 3 was selected as being a compromise between the two factors mentioned above.

The first phase of subject selection consisted of obtaining measures of reading proficiency and intellectual development for a sample of grade-3 readers. The readers were obtained from six schools in the Hamilton Public School system. The six schools were all "inner city" schools whose children generally come from lower socio-economic strata. Records for all children in grade 3 from these schools were obtained. The measure of reading proficiency used was either the Gates-MacGinitie Primary level 2 test administered in May of the child's grade-2 year or the Gates-MacGinitie Primary Level 3 test administered in September of the child's grade-3 year. It was unfortunately not feasible to standardize time of test and reading test used. It should be noted however, that children tested in these two ways should not differ substantially in terms of amount of formal reading instruction so that the scores obtained should be reasonably well related.

The measure of intellectual development used was the Primary Mental Abilities (1963) test. It had been uniformly administered to this population at the end of their first year in school. Only those children for whom both measures were available were included in subsequent work; this yielded a population of 202. Two reading scores - vocabulary (RVOCAB) and comprehension (RCOMPR) subscales and five IQ scores - verbal (IQVERB), perceptual speed (IQPSPEED), number (IQNUMB) and spatial ability (IQSPAT) subscales as well as an IQ TOTAL score (IQTOT) were thus available.

As a preliminary analysis, univariate statistics were compiled for each of these seven IQ and reading scores. The obtained values are close to what might be expected as can be seen from Table 1. Also to be found in Table 1 is an intercorrelation matrix which yielded the correlations necessary to generate regression equations of reading onto IQ. One comment on the correlation matrix seems in order. The obtained correlations between reading scores and IQ scores range from .212 to .391. These values are lower than values typically found for comparable comparisons; for example, Willows (1974) found a correlation of .54 between the Gates-MacGinitie and an IQ test. The lower values found here are understandable in view of the one-year lag between IQ and reading-test administration.

In a factor analysis (done by the BIOMED program BMDP4M, 1976), two major factors emerged. The first factor loaded heavily on IQ scores and accounted for 53% of the common variance; the second factor loaded heavily on reading scores and accounted for a further 19% of the variance. It is of interest to note that not all the variance in reading scores is accounted for by variance in IQ.

The second phase of subject selection involved choosing 27 poor readers and 13 good readers for the work of the current thesis. Several criteria had to be met before a particular child was included:

1) IQ scores from the normal range were required for all readers.

2) for poor readers, reading scores should be lower than expected based on IQ, for good readers, reading scores should be higher. Only reading scores 1/2 standard-deviation higher or lower than expected based on I.Q. scores were considered.

3) reading scores based on an average of the vocabulary and

Table 1

UNIVARIATE SUMMARY STATISTICS

	VARIABLE	MEAN	STANDARD DEVIATION
1	RVOCAB	3.01 (grade level)	.95
2	RCOMPR	2.86 (grade level)	1.01
3	IQVERB	100.	11.9
4	IQPSPEED	113.	16.1
5	IQNUMB	104.	12.0
6	IQSPAT	101.	13.4
7	IQTOT	104.	

CORRELATION MATRIX

		RVOCAB 1	RCOMPR 2	IQVERB 3	IQPST 4	IQNUMB 5	IQSPAT 6	IQTOT 7
RVOCAB	1	1.000						
RCOMPR	2	.738	1.000					
IQVERB	3	.289	.334	1.000				
IQPSPEED	4	.212	.280	.360	1.000			
IQNUMB	5	.241	.304	.600	.497	1.000		
IQSPAT	6	.212	.274	.337	.403	.405	1.000	
IQTOT	7	.312	.391	.796	.731	.816	.647	1.000

UNIVARIATE SUMMARY STATISTICS AND CORRELATION MATRIX FOR READING AND IQ SCORES FROM A SAMPLE OF 202 GRADE 3 READERS.

comprehension subscales of no higher than 2.0 for poor readers and no lower than 3.5 for good readers were required.

4) A very important overriding criterion for selection in this phase was provided by teacher opinion. Potential good readers who met all of the above criteria were included only if their teachers agreed that they were "good" readers. Potential poor readers again had to be labelled so by their teachers to justify inclusion.

5) All poor readers meeting the above criteria also had been singled out by remedial reading teachers as being below average and were at the beginning of this work all receiving remedial instruction.

6) Finally, no children with obvious behavioral problems or gross perceptual handicaps were selected. Also, new immigrants were not considered as this was not a study of second-language learning.

Stimuli

The word lists used were adapted from Baron (1979) and consisted of 32 orthographically regular and 32 orthographically irregular English words as well as 32 pronounceable nonwords (the lists can be found in Appendix 1). As with Baron, the question of orthographic regularity was decided by consulting Venezky (1970). Each of the 96 letter strings was printed in lower case letters on standard index cards. Ascending and descending letters (e.g. t, p) were 2.5 cm (4 lines) high, and other letters were half that height.

Procedure

Each child was seen individually in a session lasting about 1.5 h for poor readers, 1 h for good readers. Sessions were carried out in privacy in whatever room a particular school had available. The first five to ten minutes of each session were used to familiarize the child with the experimenter and the apparatus. Following a brief "chit-chat", each child was introduced to the workings of the tape recorder used during the session (a Sony TC200) as well as to a telegraph key to be discussed shortly. This was done by some casual recording of the experimenter and child talking followed by an opportunity for the child to listen through headphones to what had been recorded.

Following this familiarization period, the child was seated across a desk or table from the experimenter and facing him with the tape recorder microphone situated unobtrusively to one side. The child was simply informed that 64 words (in fact the 32 regular and 32 irregular words in random order) would be presented one at a time for reading aloud and that responses would be recorded. A black microphone case (15 x 25 cm) was placed on the desk and the deck of 64 regular and exception words was placed so that it was hidden from the child. A demonstration of a single one-word trial followed, using a blank card. Finally, all 64 words were presented one at a time and the child's responses were recorded.

Any single trial had the following structure. The card was placed on top of the microphone case, thus exposing it to the child's full view. At this instant, the key on a standard telegraph key was depressed. The card remained in full view until a response was completed. If about 10 s passed without a response, the child was encouraged to emit one. At the termination of the response, the telegraph key was once more depressed, and a new trial began.

Recording was on one channel only for the child's response and on the other channel for the telegraph key. The key presses generated small "clicks" on one channel, thus leaving a record which could be computer-analyzed for response latency. Pilot work had shown that any attempt to record latency to response onset (as opposed to offset) would lead to tremendous problems since comparable children were prone to make false starts. This problem as well as that of extraneous vocalizations precluded use of a voice-key and led to the present apparatus. Beyond noting that response latencies were taken, they will not be dealt with further in this thesis.

Following this, the 32 nonwords were similarly presented. Before presentation, children were informed that "these words aren't real words. If you look them up in a dictionary you won't find them. But you can read them anyway".

Following completion of the nonword set, the child was given a piece of paper and a pen or pencil and asked to spell the 64 words. The experimenter vocalized each to-be-spelled word once, then used it in a sentence and then vocalized it again. For example, the word 'HONEY' was used in the sentence 'BEES MAKE HONEY'.

For the entire session, the child was allowed to determine pacing including short breaks (less than 5 min) between tasks. Unconditional positive comments were frequently made by the experimenter especially when children seemed to become frustrated at failures.

Results and Discussion

Recorded responses were transcribed for data analysis and several measures including those mentioned in the introduction were tabulated (REG-IRREG, CON-LIB, NW-W, REG PRO, NW-W NONWORD, REG-IRREG SP, CON-LIB SP). The additional variables include:

1) TIME IR - the time taken to read the 64 irregular and regular words. The units of measurement of this variable are defined by the tape index - counter on the tape recorder. 1 unit corresponds to about 5 sec.

2) TIME N - the time taken to read the 32 non-words.

3) RVERB & RCOMPR - The Gates-MacGinitie verbal and comprehension scores respectively.

4) IQVERB, IQPSPEED, IQNUMB, IQSPAT & IQTOT - The PMA. verbal, perceptual speed, number and spatial abilities subscale scores and the overall PMA score respectively.

As a preliminary step, data for the poor and good readers were analysed separately. Results for the poor readers will be considered first. Table 2 contains means and standard deviations for all of these variables. Means on the reading scores are appropriately low as compared with the overall means for the population from which this sample was drawn and IQ scores are normal. Standard deviations on the first seven variables are quite high indicating a good range of scores on those variables.

Table 3 also contains an intercorrelation matrix for these data. Several important results emerge. The most important result is that the intercorrelations among the first seven variables are uniformly high with the lowest correlation being .481. This high intercorrelation pattern provides evidence that the types of errors and

TABLE 2

UNIVARIATE SUMMARY STATISTICS

	VARIABLE	MEAN	STANDARD DEVIATION
1	REG-IRREG	4.56	4.94
2	CON-LIB	-5.74	19.38
3	NW-W	-4.26	14.20
4	REG PRO	11.37	7.75
5	NW-W NONWORD	-.81	7.41
6	REG-IRREG SP	4.93	3.95
7	CON-LIB SP	7.07	26.48
8	TIME IR	38.19	14.57
9	TIME N	20.07	7.14
10	R VERB	1.77	.31
11	R COMPR	1.57	.29
12	IQ VERB	98.	10.7
13	IQPSPEED	111.	16.2
14	IQNUMB	103.	10.7
15	IQSPAT	99.	13.0
16	IQTOT	101.	9.7

UNIVARIATE SUMMARY STATISTICS FROM A SAMPLE OF 27 POOR READERS.

TABLE 3

CORRELATION MATRIX

		REG-IRREG 1	CON-LIB 2	NW-W 3	REG PRO 4	NW-W NONWORD 5	REG-IRREG SP 6	CON-LIB SP 7	TIME IR 8
REG-IRREG	1	1.000							
CON-LIB	2	.689	1.000						
NW-W	3	.637	.916	1.000					
REG PRO	4	.598	.767	.624	1.000				
NW-W NONWORD	5	.481	.695	.758	.483	1.000			
REG-IRREG SP	6	.544	.688	.670	.573	.563	1.000		
CON-LIB SP	7	.558	.745	.724	.614	.669	.620	1.000	
TIME IR	8	.164	.108	.105	-.251	.236	-.173	-.002	1.000
TIME N	9	.155	.123	.143	-.199	.322	-.199	.029	.902
R VERB	10	.197	.199	.011	.350	-.143	.276	.174	-.402
R COMPR	11	-.122	.262	.231	.322	-.064	.316	.107	-.392
IQ VERB	12	.334	.258	.194	.241	.399	.194	.116	.016
IQPSPEED	13	.170	.299	.129	.516	.207	.237	.092	-.183
IQNUMB	14	.231	.206	.136	.190	.412	.271	.272	-.007
IQSPAT	15	.447	.457	.344	.501	.399	.021	.141	.407
IQTOT	16	.382	.379	.252	.466	.461	.226	.176	.070

		TIMEN 9	READV 10	READC 11	IQVERB 12	ISPST 13	IQNUMB 14	IQSPAT 15	IQTOT 16
TIME N	9	1.000							
R VERB	10	-.443	1.000						
R COMPR	11	-.340	.317	1.000					
IQ VERB	12	.058	.192	.038	1.000				
IQPSPEED	13	-.165	.149	.253	.318	1.000			
IQNUMB	14	-.056	.037	.033	.494	.645	1.000		
IQSPAT	15	.321	.030	-.230	.280	.296	.152	1.000	
IQTOT	16	.057	.134	.017	.790	.753	.739	.564	1.000

CORRELATION MATRIX FOR 16 SCORES FROM A SAMPLE OF 27 POOR READERS types of successes generated by poor readers while reading and spelling are not a random collection. In addition the theoretical conception of two idealized reading strategies proves to be extremely useful in uncovering these regularities. The finding of the predicted regularities can be taken as validating the theoretical conception which generated those predictions.

A second result of interest is the finding of uniformly low correlations of the time and reading score variables with any of the previously mentioned recoding-whole-word indicator variables. The highest correlation of any of these four variables with any of the seven indicator variables is .350. The same pattern of low correlation is found between these four measures and the five IQ values where the highest correlations are .407, .321, and .253.

The third result of interest is one which was unexpected. This is the finding of correlations somewhat higher than expected between the five IQ scores and the seven indicator variables. Of the 35 possible correlations, two were above .5 and five were above .4. This was unexpected since care was taken to keep IQ scores close to normal.

A more concise way of expressing these inter-relationships is the factor analysis. In a factor analysis (again from BMD, BMDP4M, 1976) three principal factors emerged, each accounting for more than 10% of the total variance in the overall data matrix. When these three factors are rotated to maximize variance accounted for, the three factors are easily interpretable. Table 4 contains the loading of each of 16 variables on each factor. As can be seen, the first factor is comprised of the block of 7 indicator variables. This will be

Table 4

ROTATED FACTOR LOADINGS

		FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
REG-IRREG	1	.654	.164	.118	.457
CON-LIB	2	.896	.154	-.014	.301
NW-W	3	.932	.050	.063	.105
REG PRO	4	.652	.256	-.330	.501
NW-NONWORD	5	.779	.360	.312	-.061
REG-IRREG SP	6	.800	.140	-.309	-.062
CON-LIB SP	7	.866	.048	-.056	-.004
TIME IR	8	.068	-.024	.900	.103
TIME N	9	.114	-.026	.894	.037
R VERB	10	.062	.035	-.632	.483
R COMPR	11	.228	.043	-.622	-.133
IQ VERB	12	.126	.742	.043	.167
IQPSPEED	13	.090	.781	-.252	.150
IQNUMB	14	.169	.869	-.014	-.210
IQSPAT	15	.205	.310	.388	.746
IQTOT	16	.164	.931	.061	.293

ROTATED FACTOR LOADINGS FOR 16 SCORES FROM A SAMPLE OF 27 POOR READERS.

tentatively labelled as the whole-word - recoding factor and it accounted for 37% of the total variance. The second factor loads most heavily on the five IQ scores although curiously, IQSPAT shows a low loading. This factor will thus be labelled a general intelligence factor. It accounts for a further 19% of the variance. The third factor loads heavily on the time and reading variables and as such can be identified as a reading ability factor. It accounts for a further 16% of the total variance. Factor four accounts for only 7%.

Several important points must be made. First, these factors are of course orthogonal or uncorrelated. This means that variability along one factor cannot be accounted for by another. This fact provides a resolution for the problem of IQ scores correlating with the indicator variables since even after the IQ factor is separated out, a recoding - whole-word factor remains. Finally, the separation of reading score and speed scores into a factor orthogonal to IQ scores supports the notion that general intelligence is not the sole determinant of reading ability. In this vein, the finding that the IQ and reading factors are orthogonal to the recoding - whole-word factors suggests that different skills for reading can be found, independent of IQ and overall reading ability.

In the present context, readers who are poor at what they do across a variety of assessment methods turn out to be very non-homogenous with respect to reading skill. For this reason, it is possible to reject any theories of reading difficulties which imply that the population of poor readers is uniform in skill preference. Thus, the notion that poor readers are poor because they fail to recode (e.g., Rozin & Gleitman, 1976) is inadequate because in the present study, evidence can be found for individuals who read poorly and yet rely heavily on a recoding skill. Similarly, the notion that poor readers are poor because they have failed to transcend a pure recoding skill to rely more heavily on a whole-word skill (Smith, 1973) is inadequate because it fails to account for poor readers from the present study who fall on the other end of the recoding - whole-word continuum, rely heavily on a whole-word skill and yet still have reading problems.

Data from the set of 13 good readers were also analyzed with these questions in mind. Table 5 presents the intercorrelation matrix for all 16 variables. Several important departures from the patterns for poor readers can immediately be found. First and most important, intercorrelations among the seven indicator variables are not as high; 12 of the 21 correlations are in fact negative. There is thus no evidence in the present study that a recoding - whole-word factor describes good readers.

At first, this result may seem to conflict with earlier cited data by Baron and Strawson (1976) on skill preferences in adults. In actuality, no such conflict has been shown to exist. The 7 variables of the present indicator set ~~are~~ primarily concerned with performance as measured by accuracy whereas Baron and Strawson (1976) use latency differences as measures of performance. It is clear that performance differences which fail to emerge in accuracy differences (in Baron & Strawson's work, error rates across conditions were relatively low) can nevertheless emerge as latency differences. Absolute levels of

TABLE 5

CORRELATION MATRIX

		REG-IRREG 1	CON-LIB 2	NW-W 3	REG PRO 4	NW-W NONWORD 5	REG-IRREG SP 6	CON-LIB SP 7	TIME IR 8
REG-IRREG	1	1.000							
CON-LIB	2	.410	1.000						
NW-W	3	-.387	-.389	1.000					
REG PRO	4	-.222	-.013	.271	1.000				
NW-W NONWORD	5	-.026	-.269	.519	.276	1.000			
REG-IRREG SP	6	-.431	-.383	.096	-.406	.038	1.000		
CON-LIB SP	7	-.412	.171	-.420	.072	-.347	.436	1.000	
TIME IR	8	-.077	-.004	.190	-.150	-.185	.062	-.195	1.000
TIME N	9	-.002	-.123	.231	.210	.068	.023	-.358	.781
R VERB	10	.563	.351	-.277	-.238	.040	-.274	.012	-.215
R COMPR	11	.212	.389	-.106	.042	.344	-.217	.292	-.549
IQ VERB	12	-.318	.131	-.206	.247	-.283	.003	.667	-.191
IQPSPEED	13	-.207	-.446	-.198	-.148	.117	.310	.310	-.431
IQNUMB	14	-.085	.015	-.210	.465	-.267	-.613	.038	-.420
IQSPAT	15	.066	.390	.177	.170	.185	-.390	-.132	-.373
IQTOT	16	-.208	.063	.262	.307	-.203	-.256	.428	-.538

		TIMEN 9	READV 10	READC 11	IQVERB 12	ISPST 13	IQNUMB 14	IQSPAT 15	IQTOT 16
TIME N	9	1.000							
R VERB	10	-.496	1.000						
R COMPR	11	-.651	.675	1.000					
IQ VERB	12	-.451	.389	.351	1.000				
IQPSPEED	13	-.536	.396	.443	.446	1.000			
IQNUMB	14	-.334	.121	.176	.478	.223	1.000		
IQSPAT	15	-.378	.205	.440	-.147	-.076	.148	1.000	
IQTOT	16	-.644	.433	.498	.823	.600	.795	.181	1.000

CORRELATION MATRIX FOR 16 SCORES FROM A SAMPLE OF 13 POOR READERS performance (as will shortly be seen) were quite high for good readers, leading to a ceiling effect. That is, these measures were not subtle enough to distinguish among good readers showing skill preferences.

An alternate means of expressing this is that while good readers may have skill preferences, these preferences are not held to the extent that accuracy of performance is damaged. In contrast, the extreme skill preferences of poor readers may actually lead to inabilities to identify correctly large numbers of words at any speed.

Results from the factor analysis are also less clear than those for poor readers. In Table 6, the rotated factor loadings are presented for good readers. Reinforcing the conclusions derived from inspection of the intercorrelation matrix concerning the absence of a recoding - whole-word factor is a failure to find one here. The first factor which accounts for 30% of the total variance is a combination IQ-reading ability factor and the remaining factors seem to defy convenient interpretation.

As a final step in subject selection, the remaining 26 poor readers (one moved away), were used to select two groups of 10. The sole criterion for selection was again supplied by the BMD factor analysis program. Each subject was assigned a weight on each factor and these weights for the recoding-whole-word factor supplied that criterion. Weights ranged from negative to positive values where a zero weight indicates that the recoding-whole-word dimension did not characterize a particular subject well. Ten children had negative weights and hence formed one group (the whole-word group) and the ten

Table 6

ROTATED FACTOR LOADINGS

		FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5
REG-IRREG	1	.200	-.125	-.740	-.351	.344
CON-LIB	2	.106	.006	.017	-.302	.924
NW-W	3	-.223	-.010	.093	.815	-.067
REG PRO	4	-.143	.744	.175	.410	.114
NW-NONWORD	5	.231	-.108	-.278	.811	-.114
REG-IRREG SP	6	-.058	-.711	.495	.075	-.412
CON-LIB SP	7	.223	-.091	.899	-.184	.106
TIME IR	8	-.741	-.235	-.041	-.135	.050
TIME N	9	-.861	-.054	-.206	.101	-.034
R VERB	10	.731	-.049	-.243	-.302	.219
R COMPR	11	.857	.024	.056	.139	.342
IQ VERB	12	.390	.366	.652	-.327	-.035
IQPSPEED	13	.702	-.024	.213	-.080	-.593
IQNUMB	14	.254	.906	.045	-.220	-.098
IQSPAT	15	.375	.189	-.122	.416	.558
IQTOT	16	.625	.614	.380	-.230	-.097

ROTATED FACTOR LOADINGS FOR 16 SCORES FROM A SAMPLE OF 13 GOOD READERS.

children with the largest positive weights formed the second group (the recoding group). The six childen with intermediate weights were not considered further. Table 7 contains the means, and standard deviations for all sixteen variables for the resulting groups. Also, included are t-test results for comparisons of recoding poor readers and whole-word poor readers on each of the 16 variables. These t-tests show that these two groups differ significantly on each of the seven indicator variables and on none of the remaining control variables. Thus, this selection method results in two groups which differ in their reliance on one of the two reading skills over another but not in general intelligence or reading ability. In addition, 10 of 12 good readers were chosen as a comparison group strictly with an aim to matching IQ with the poor readers. Means and standard deviations for the good readers for all sixteen variables are also found in Table 7. Matching for IQ was successful as the five IQ values do not differ from those of the poor readers while the four reading related measures reveal a large difference.

In order to confirm that the reading-test results describe the overall reading performance of these three groups, accuracy in reading the 64 English words was examined. The performance of good readers was close to ceiling with mean (S.D.'s in parentheses will always follow means) number of words read correctly (out of 32) being 29.9(1.37) for the regular words and 26.0(1.41) for irregular words, a significant difference, $t(9) = 6.26$. (For all significance tests in the current work, $\alpha = .05$). This performance level was well above that of the two poor reading groups, as might well be expected.

Table 7

		WHOLE-WORD POOR READERS	RECODING POOR READERS	t*	GOOD READERS
REG-IRREG	1	1.3(2.95)	7.9(5.59)	4.337	3.9(1.97)
CON-LIB	2	-23.7(8.87)	9.5(10.3)	5.929	3.9(3.63)
NW-W	3	-17.3(13.74)	6.3(7.45)	4.935	-.9(2.47)
REG PRO	4	4.6(5.19)	15.5(5.95)	3.537	22.2(1.99)
NW-NONWORD	5	-.5.4(9.07)	3.8(3.49)	3.249	2.2(3.49)
REG-IRREG SP	6	2.0(2.4)	7.8(3.82)	4.949	3.9(2.6)
CON-LIB SP	7	-18.(24.53)	29.8(9.16)	5.391	5.7(2.58)
TIME IR	8	40.(13.39)	41.7(15.23)	.235	23.4(3.03)
TIME N	9	20.1(5.84)	21.9(7.31)	.504	13.4(1.43)
R VERB	10	1.68(.33)	1.8(.35)	.660	4.25(.44)
R COMPR	11	1.42(.26)	1.6(.27)	1.466	4.18(.57)
IQ VERB	12	97.3(9.89)	97.5(12.42)	.041	98.1(10.13)
IQPSPEED	13	108.7(8.29)	114.8(16.52)	1.409	109.7(10.03)
IQNUMB	14	102.(11.45)	107.4(7.15)	1.591	103.9(13.18)
IQSPAT	15	96.1(9.31)	99.9(10.87)	.733	98.3(9.35)
IQTOT	16	100.4(7.82)	103.5(10.09)	1.134	101.2(6.2)

*t values test for differences between the two types of poor reader. t critical (9), = 05 = 2.262.

MEANS AND STANDARD DEVIATIONS FOR 16 VARIABLES FOR THREE GROUPS OF READERS. ALSO INCLUDED ARE T-TEST VALUES FOR COMPARISONS AMONG THE TWO TYPES OF POOR READERS ON EACH OF THE 16 VARIABLES.

The data for the recoding poor readers and whole-word poor readers were analysed using a two-way analysis of variance with reader type as a between-subjects variable and regular vs. irregular word as a within-subjects variable. The first finding of interest is the significant reader effect, $\underline{F}(1,18) = 11.3$. This was an unexpected finding since performance on the reading tests was equivalent. In addition, the regular - irregular effect was significant, $\underline{F}(1,18) = 21.2$, replicating the pattern for good readers. Finally, the interaction was significant, $\underline{F}(1,18) = 10.9$; this is another way of testing for differences in REG-IRREG defined earlier.

Means were 12.1(5.97) and 10.8(3.85) for whole-word poor readers on regular and irregular words respectively, a non-significant difference, $\underline{t}(9) = 1.40$, as predicted. Values for recoding poor readers were 22.4(5.13) and 14.5(5.46) respectively, a significant difference, $\underline{t}(9) = 4.47$, as expected. Three curious results need to be briefly discussed. The first, as mentioned earlier, is the finding that recoding poor readers are more often correct than whole-word poor readers. Since different factors are likely to control the probability of word identification for the two groups, actual performance may vary as a function of the particular word set used and hence such differences are not altogether surprising.

Second, even when performance on the set of irregular words is examined, recoding poor readers did better than whole-word poor readers (14.5 vs 10.8). While the difference is much smaller here than for regular words, one might have expected recoding poor readers to do exceptionally poorly here. Third, even on regular words where recoding readers should excell, good readers performed better than poor readers (29.9 vs 22.4, t(9) = 4.69).

Points two and three together emphasize that no poor reader here was using a pure recoding or whole-word skill. Recoding poor readers must have some whole-word memory. That this memory emerges here is not surprising since most of the words used here are extremely common, having been formally introduced by Grade 1. The recoding skill which is used is also not as efficient as that of good readers since errors are generated on perfectly pronounceable words. These poor readers may generate correct pronunciations for some irregular words by applying inappropriate pronunciation rules. For example, the pronunciation contrast signaled by a silent E plays a role in a substantial number of regular and irregular words in the present set. A recoding poor reader who only sometimes applied this rule properly would make errors on some regular words and get some irregular words correct by chance.

To demonstrate more clearly the nature of these three groups, the whole-word poor readers, the recoding poor readers and the good readers, a final factor analysis of the data for all sixteen variables across these 30 children was undertaken. The resulting inter-correlation matrix for these variables is to be found in Table 8 and the rotated factor loadings for each variable on each factor is found in Table 9. In general, these results parallel those for the poor reader group alone. The first factor (the whole-word - recoding factor) accounts for 35% of the total variance and comprises the seven indicator variables. The second factor accounts for 22% of the total

TABLE 8

CORRELATION MATRIX

		REG-IRREG 1	CON-LIB 2	NW-W 3	REG PRO 4	NW-W NONWORD 5	REG-IRREG SP 6	CON-LIB SP 7	TIME IR 8
REG-IRREG	1	1.000							
CON-LIB	2	.686	1.000						
NW-W	3	.605	.923	1.000					
REG PRO	4	.422	.728	.587	1.000				
NW-W NONWORD	5	.465	.681	.768	.501	1.000			
REG-IRREG SP	6	.561	.596	.658	.329	.521	1.000		
CON-LIB SP	7	.562	.751	.725	.501	.690	.614	1.000	
TIME IR	8	.170	-.011	.064	-.477	.125	.033	.078	1.000
TIME N	9	.157	-.005	.108	-.447	.233	.025	.127	.912
R VERB	10	.015	.308	.148	.676	.167	-.087	.035	-.639
R COMPR	11	-.048	.327	.205	.689	.226	-.094	.018	-.631
IQ VERB	12	.317	.207	.123	.170	.282	.136	.136	.080
IQPSPEED	13	.220	.157	.184	.249	.239	.212	.124	-.052
IQNUMB	14	.251	.126	.136	.117	.263	-.036	.255	.106
IQSPAT	15	.447	.427	.338	.321	.364	.085	.225	.379
IQTOT	16	.395	.283	.230	.257	.391	.138	.225	.164

		TIMEN 9	READV 10	READC 11	IQVERB 12	ISPST 13	IQNUMB 14	IQSPAT 15	IQTOT 16
TIME N	9	1.000							
R VERB	10	-.647	1.000						
R COMPR	11	-.613	.953	1.000					
IQ VERB	12	.129	.082	.050	1.000				
IQPSPEED	13	-.040	-.069	-.010	.355	1.000			
IQNUMB	14	.134	-.061	-.035	.458	.336	1.000		
IQSPAT	15	.210	-.005	.037	.011	.147	.113	1.000	
IQTOT	16	.164	-.029	-.003	.813	.673	.719	.339	1.000

CORRELATION MATRIX FOR 16 SCORES FROM A SAMPLE OF 10 WHOLE-WORD POOR READERS, 10 RECODING POOR READERS, AND 10 GOOD READERS.

Table 9

ROTATED FACTOR LOADINGS

		FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
REG-IRREG	1	.709	-.069	.265	.200
CON-LIB	2	.883	.249	.089	.253
NW-W	3	.911	.099	.052	.164
REG PRO	4	.563	.716	.161	.167
NW-NONWORD	5	.749	.071	.237	.272
REG-IRREG SP	6	.842	-.118	.029	-.322
CON-LIB SP	7	.857	-.021	.097	.020
TIME IR	8	.065	-.823	.038	.483
TIME N	9	.105	-.820	.071	.385
R VERB	10	.056	.937	-.026	.138
R COMPR	11	.062	.936	-.011	.177
IQ VERB	12	.103	.017	.811	.014
IQPSPEED	13	.166	.025	.701	-.152
IQNUMB	14	.054	-.054	.758	.132
IQSPAT	15	.290	-.036	.095	.804
IQTOT	16	.169	-.031	.955	.197

ROTATED FACTOR LOADINGS FOR 16 SCORES FROM A SAMPLE OF 10 WHOLE-WORD POOR READERS, 10 RECODING POOR READERS, AND 10 GOOD READERS.

variance and loads on the reading scores and speed scores (the reading factor). The third factor accounts for 14% of the total variance and loads on four of the five IQ scores (the IQ factor).

In order to make clear the nature of these factors, factor weights (for each of the three factors) were used to rank the 30 children independent of group on each of the three factors. Following this, the mean rank was calculated for each group on each factor. The results are found in Table 10. Beginning with the whole-word-recoding factor, low ranks are closer to the whole-word end of the factor. As can be seen, the whole-word poor readers had the lowest mean ranks and recoding poor readers had the highest mean rank with normals being intermediate. The whole-word recoding factor is an excellent tool for separating out the three groups as a Kruskal-Wallis test (Gibbons, 1976) for differences among these means was significant, $H = 29.5$, and a planned multiple comparison (Dunn's test, see Gibbons, 1976) revealed that all three mean ranks differ from one another ($\alpha < .10$). the separation of these three reading groups by the recoding - whole-word factor is made more impressive by the fact that the lowest eight weightings in this factor corresponded to whole-word poor readers and the highest eight corresponded to recoding poor readers and no overlap between the two groups of poor readers was found. That good readers fall in between the two poor reading groups is anticipated since earlier it was shown that the good readers as a group were relatively homogenous with respect to the recoding - whole-word factor. This was true since no such factor emerged from the analysis of responses of good readers alone.

Table 10

	RECODING WHOLE WORD FACTOR	READING & SPEED FACTOR	IQ FACTOR
GOOD READERS	16.3	25.5	15.2
RECODING POOR READERS	25.3	10.1	16.6
WHOLE-WORD POOR READERS	6.6	10.9	14.7

MEAN RANKS FOR EACH GROUP OF READERS ON EACH FACTOR. RANKS FOR INDIVIDUALS WERE SUPPLIED BY BMDP4M.

Analysis of the reading factor again revealed a significant difference by a Kruskal-Wallis test, H = 19.5, and Dunn's multiple planned comparison procedure revealed that the good reading group differed significantly from the other two (α = .05). Quite simply, the ten highest ranks, indicating good reading performance, were assigned to the good readers. It is also important to note that the two groups of poor readers can not be differentiated by this factor.

Finally, the IQ factor is not able to distinguish among these groups at all. The Kruskal-Wallis test fails to find any difference between the ranks (H = .250).

To summarize, three groups of 10 readers per group have been isolated with several properties.

1) IQ's (P.M.A.) do not distinguish the groups.
2) A group of good readers and two groups of poor readers can be delineated based on reading scores (Gates-MacGinitie) and response latency scores. The poor readers seem to be equally poor on these measures.
3) The two poor reading groups can be distinguished in terms of a different dimension, here labelled a whole-word - recoding dimension, referring to the degree of preference which readers show for one skill over another. When all 30 readers are ranked on this dimension, good readers are intermediate. This may be taken to show that these good readers do not show marked skill preferences.

Study 1 establishes that the population of poor readers can be ordered along a dimension. Based on predictions derived from a consideration of two idealized reading skills, recoding and whole-word, this dimension has been labelled a recoding - whole-word dimension. It would be desirable to substantiate this distinction experimentally. To this end, the three groups of 10 readers isolated in Study 1 participated in a set of five experiments designed to examine the two key differences between the reading skills: reliance on a sound based code and reliance on whole-word configurations as discussed in Section one.

Experiment 1

Introduction

This experiment dealt with the question of recoding by using one of the diagnostics of Baron and Strawson (1976) as discussed in the introduction. Basically, the task involved presenting a set of pronounceable nonwords, half of which sound like an English word (e.g. 'FEAL') and half which do not (e.g. 'GEAL'). Subjects were required to indicate for each non-word whether or not it sounded like a real word. What Baron and Strawson found was that some adults were better at making this judgment than others. This task requires that sound values be derived for (by definition) unfamiliar stimuli. If stimuli are kept relatively simple, recoding poor readers should do fairly well whereas whole-word poor readers should do quite poorly. Secondly, following Study 1, recoding poor readers should do worse than good readers.

Method

Subjects. The three groups of 10 readers isolated in Study 1 participated.

Stimuli. A set of 32 non-words was constructed and printed individually on index cards as in Study 1. Half of the non-words sound like an English word, half do not. The full set is listed in Appendix 2. Some comments on this stimulus set are in order. This set is based on four pairs of English spelling patterns which are pronounced similarly: 'ITE' vs 'IGHT' as in 'KITE' vs 'BRIGHT', 'O_E' vs 'OA' as in 'HOME' vs 'BOAT', 'EE' vs 'EA' as in 'FEEL' vs 'SEAT', and 'A_E' vs 'AI' as in 'DATE' vs 'WAIT'. The resulting pronunciation patterns conform to rules of English to which these children have been formally exposed. Thus, it is relatively easy to derive actual sound values for these stimuli.

A second point to note is that the two different sets of nonwords do not differ in any orthographic sense whatsoever. The only way to discriminate these two sets is on the basis of this relation to a real word. It is also not possible to argue that one set "looks more like words" since for example 'DAIT' differs from 'DATE' much more than for example 'GITE' differs from, say, 'GATE' on a purely visual basis.

Procedure. Each child was seen individually for a self-paced session lasting from 10 to 20 min. Since these children already had experience reading nonwords in Study 1, it was a simple matter to introduce this task in the following way: "Do you remember reading some words which aren't real once before? Well today I have 32 more of those words. Again, none of these words are real. If you look them up in the dictionary you won't find them. Some of these words sound like real words, some of them don't. I will show you them one at a time. If you think what I am showing you sounds like a real word, say yes and if you think it doesn't, say no. O.K.?"

The deck of index cards was re-shuffled for each child and cards were exposed one at a time as in Study 1. When a decision was made by the child, a new card was exposed.

Results and Discussion

Because of the structure of the task, it was possible to analyse the result by d' scores (from tabled values in Elliot, 1964), where d' is an index of how well the two sets of non-words were discriminated (a larger d' means better discrimination). Accordingly, d' values were calculated for each subject and formed the raw data for analysis.

Two very simple analyses convey the results of interest. First, whole-word poor readers showed lower d' values than recoding poor readers as predicted $\underline{t}(9) = 4.40$, one-tailed. Mean d' values with mean probability of hits in parentheses were .83(.64) for whole-word poor readers and 2.56(.85) for recoding poor readers. On the second comparison of interest, good readers, with a mean d' of 3.21(.85), showed even better discriminability than recoding poor readers, although the difference was not significant, $\underline{t}(9) = 1.37$, one-tailed. Overall, this pattern of results also held for hits.

The difference between the two groups of poor readers in the ability to recode visually presented stimuli is brought out in sharp relief by the current manipulation. When familiarity is controlled, here by effectively making all of these items novel, whole-word poor readers are at quite a loss as to what to do. Only one recoding poor reader did worse than any whole-word poor reader, strongly suggesting that this task would be diagnostically effective on its own for separating poor readers into these two groups.

A second point concerns the finding that recoding poor readers do worse than good readers in this task. In spite of the fact that this difference fails to reach significance here, the obtained difference as well as the difference obtained in Study 1 between good readers and recoding poor readers begins to suggest that the pronunciation rules which the recoding poor readers have induced are not as effective at generating correct pronunciations as those of good readers. That is, recoding poor readers may be poor readers for two reasons. First, they do not utilize a whole-word skill often enough, and second, the recoding skill which they use is not optimally operative. This issue will be addressed further in the general discussion.

It will be recalled that Firth (1972) found that the ability to decode nonsense syllables was the best single predictor of overall reading performance. This, in fact, is not unreasonable since a comparison of the good readers with the 20 poor readers pooled together would show a significant difference in the current experiment. The problem is with Firth's interpretation of this finding. This finding was interpreted as revealing that a decoding or recoding deficit underlies poor reading and, by implication, that all poor readers share the same problem. In light of the clear difference between the two groups of poor readers, this implication must be seriously questioned.

Experiment 2

Introduction

The question of recoding has been dealt with by Rubenstein, Lewis and Rubenstein (1971) and Meyer, Schvanevelt and Ruddy (1973) using a lexical decision task, as was mentioned in the general introduction. On any given trial, a word or nonword is presented and the subject's task is to respond appropriately. The manipulation of interest in this task concerns the nonwords. Some of the nonwords sound like words and some do not. The finding of interest is that it takes adult subjects longer to decide that nonwords which rhyme with words are in fact nonwords than nonwords which do not rhyme with words. The interpretation of this finding is that sound-based properties of words and nonwords are factors in lexical decisions (i.e., that recoding occurs prior to lexical access).

Since, as currently hypothesized, whole-word poor readers rely much less on recoding than recoding poor readers, then in a lexical decision experiment the difference between the accuracy of decision about nonwords which rhyme with words and nonwords which do not rhyme with words should be much greater for recoding poor readers than for whole-word poor readers. Since these poor readers generate many errors, this effect should be found in the probability of correct decisions rather than response latency. That is, nonwords rhyming with words should be more often incorrectly identified as words than nonwords not rhyming with words and this difference should be larger for recoding poor readers than for whole-word poor readers.' The present experiment tested this prediction.

Another technique which has been used to investigate the recoding issue is the use of concurrent vocalization as exemplified by the work of Kleiman (1975) discussed earlier. Kroll, Parks, Parkinson, Bieber and Johnson, (1970) for example showed that a concurrent shadowing task, which consists of repeating digits, disrupts recoding to speech. If a lexical decision task was used with two conditions, one as outlined above and one involving some concurrent vocalization task as well, then performance should be poorer when concurrent vocalization is required. Furthermore, since whole-word poor readers are less dependent on recoding than recoding poor readers, the concurrent vocalization manipulation should not disrupt the whole-word poor readers as much. Again, this prediction was tested in the current experiment.

To summarize, the current experiment tests two predictions concerning the performance of the two types of poor reader in a lexical decision task. These predictions are based solely on the notion that recoding poor readers rely more heavily on recoding to sound and hence a sound-based representation than do whole-word poor readers.

1) nonwords which sound like real words should generate more false alarms than nonwords which do not sound like real words, and this difference should be greater for recoding poor readers than for whole-word poor readers. This should be true since the nonwords that sound like real words are not discriminable from real words

based on sound properties alone, the only criterion available to recoding poor readers.

2) concurrent vocalization, which is thought to interfere with recoding, should produce greater performance deficits for recoding poor readers than for whole-word poor readers.

Method

Subjects. The three groups of readers defined in Study 1 participated.

Stimuli. The stimulus set of Experiment 1 was expanded in size to include 64 words and 64 nonwords. One half of the nonwords sound like English words. Two sets of 64 words with 32 words and 32 nonwords (16 sounding like English words) in each resulted and are presented in Appendix 3 as sets A and B. A nonword which sounds like an English word found in, for example, set A, will have the English word in set B and vice-versa. As before, each letter string was printed in lower case letters on a standard index card.

Procedure. Each child completed the task in an individual session requiring 45-60 min for completion. Every child first made lexical decisions concerning 64 items in the control condition and then 64 items in the concurrent vocalization condition. If set A items were used in the control condition, then set B items were used in the concurrent vocalization condition and vice-versa. In each of the three groups of readers, half began with set A, half with set B.

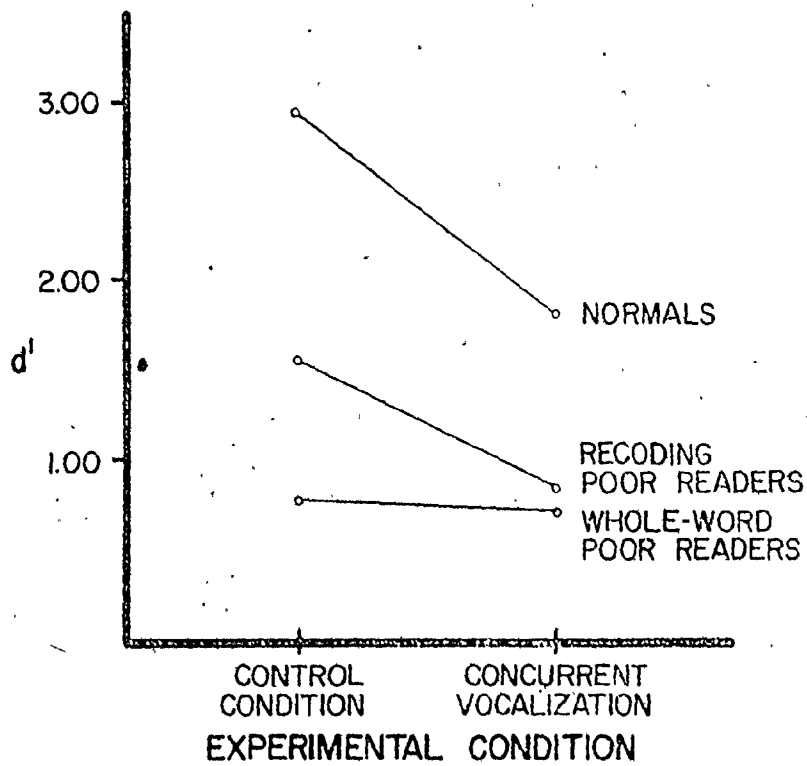
At the beginning of the session, children were told by the experimenter that "I have here a set of 64 words. Half of them are real, half aren't. They aren't real because if you look them up in the dictionary you won't find them. Half of the words which aren't real sound like real words but aren't spelled the same so you have to be careful. Now, what I will do is show you a word." At this point, a blank card was exposed in the manner that all target cards would be and as described in Study 1. Instructions continued: "If you think the word is real, nod your head, if you think it isn't, shake it. Please don't say anything". The experimenter then demonstrated nodding and shaking and asked each child to do both. Perhaps because these children had previous experience with most features of the experimental situation, all children seemed to understand what was required. Following the instructions, items were presented one at a time as in all previous work and the child's response as well as latency was recorded. These children generated a number of responses in which a decision was altered after it was first made. In this experiment, only the first decision was recorded. This was deemed absolutely necessary since in the concurrent vocalization condition to be described shortly, a strategy some children adopted was to make a decision while vocalizing, then stop, and then attempt to modify their decision if necessary. Since allowing such modifications would defeat the purpose of requiring the concurrent vocalization, they were not accepted and were hence not accepted in the control condition, to ensure comparability across conditions.

After the completion of the control set and a brief (2 min) break, the concurrent vocalization condition began. Pilot work had shown that shadowing as a concurrent task was too difficult for present purposes and it was decided instead to have children count aloud from one to ten. Instructions to each child were as follows: "For this next set, everything is like before with one exception. That is, half of these words are real, half are not, half of the words which aren't real sound real so again you'll have to be careful." At this point the experimenter demonstrated while continuing with instructions: "For this set, I will say "ready". Then you will count from one to ten - one, two, three and so on out loud. Practice once for me: Ready -- good. Now, while you are counting, I will show you a word. Don't stop counting when you see the word, and again, nod your head if you think it's real, shake it if you think it isn't. Don't stop counting until you've decided and shown me by nodding and shaking. Keep counting past 10 if you have to." All children were repeatedly encouraged to count faster if the counting rate dropped to the point where it seemed possible to vocalize in between saying two numbers.

Results and Discussion

The data of interest were classification errors and two different analyses were undertaken. The first concerned the word - nonword decision in the concurrent vocalization and control conditions. d' (Elliot, 1964) values were calculated for individuals in each of the three reading groups and for the two experimental conditions separately. Mean d' values are shown plotted in Figure 6. A two-way analysis of variance with the two poor reading groups as a between-subjects factor and the two experimental conditions as a within-subjects factor immediately confirmed one of the hypotheses of this experiment. A significant main effect of type of reader was found, $F(1, 18) = 6.98$, conceptually replicating the findings of the previous

FIGURE 6
LEXICAL DECISION



experiment that the whole-word poor readers perform worse on the average than the recoding poor readers. A significant main effect of concurrent vocalization was found, $F(1,18) = 8.27$, replicating the findings of Rubenstein et al. (1971). Most important for present purposes was the finding of a significant interaction between poor reader type and experimental condition, $F(1,18) = 5.79$. This result supports the hypothesis that recoding poor readers encounter more interference from concurrent vocalization than whole-word poor readers. Looking at whole-word poor readers only, mean d' values with mean probability of hits in parentheses were .77(.73) for control and .71(.73) for concurrent vocalizations respectively. This difference was not significant, $t(9) = .431$. Recoding poor readers showed means of 1.55(.81) and .86(.74) respectively - a significant interference effect, $t(9) = 3.15$.

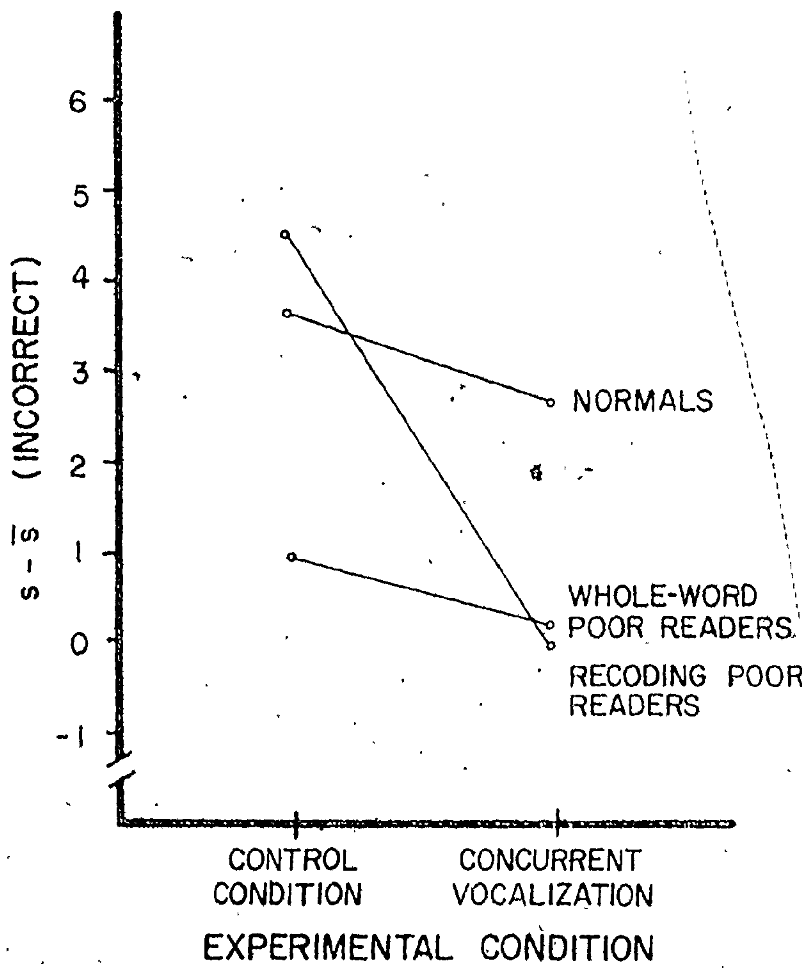
A word about the performance of good readers is in order. With means of 2.94(.96) and 1.81(.85) respectively, good readers as well showed a significant interference effect, $t(9) = 3.42$, again conceptually replicating Rubenstein et al. (1971). The fact that this effect is as large as if not larger than that found for recoding poor readers may be taken to suggest as extreme a dependence on verbal coding in good readers. Several reasons can be advanced for rejecting this interpretation. First, performance in the other experiments presented here is not consistent with this idea. Second, even under conditions of concurrent vocalization, the performance of good readers is above that of recoding poor readers in the normal condition.

Clearly, this greater level of performance must be due to some greater ability to resist the effects of concurrent vocalization.

The second analysis of interest concerns the erroneous responses to the two different types of nonwords - those that sound like English words (S) and those that do not ($\overline{S}$). In Figure 7 is plotted a difference score (S-$\overline{S}$) for control and concurrent vocalization conditions separately across the three reader groups. First consider the two poor reader groups. A two-way analysis of variance on the dependent variable S-$\overline{S}$ revealed a non-significant main effect of type of reader, $F(1,18) = 2.57$. That is while overall the difference score S-$\overline{S}$ was larger for recoding poor readers, it was not significantly so. The main effect of condition was significant, $F(1,18) = 10.0$, indicating that difference scores generally became smaller in the concurrent vocalization condition. This is to be expected since S-$\overline{S}$ indexes effects of recoding. Larger values of S-$\overline{S}$ mean that more nonwords that sound like real words are judged real than nonwords that do not sound like real words. The larger this value gets, the more of a role this sound-based difference between the two types of nonwords becomes. Since concurrent vocalization is supposed to reduce vocalization and recoding, it is thus reasonable that S-S <u>should</u> be smaller in the concurrent vocalization condition.

Of great interest for present purposes was the finding of a significant interaction between type of poor reader, and the concurrent vocalization manipulation, $F(1,18) = 4.96$. This finding can only mean that decreases in S-$\overline{S}$ as a function of concurrent vocalization are greater for recoding poor readers than whole-word poor readers. This

FIGURE 7


6
5
4
3
2
1
0
-1
s - s̄ (INCORRECT)
NORMALS
WHOLE-WORD
POOR READERS
RECODING POOR
READERS
CONTROL
CONDITION
CONCURRENT
VOCALIZATION
EXPERIMENTAL CONDITION

finding provides statistical support for the claim that concurrent vocalization should interfere more with the reading of recoding poor readers. Examined in a little more detail, mean S-$\bar{S}$ values for recoding poor readers are 4.5(3.06) in the control condition and -.1(3.14) in the concurrent vocalization condition. This drop is significant, $t(9) = 3.98$, confirming the conclusion that the effect of concurrent vocalization is to decrease reliance on recoding. Whole-word poor readers' means are .9(2.47) for the control condition and .1(3.41) for the concurrent vocalization condition, a nonsignificant decrease, $t(9) = 0.64$. This finding is consistent with the claim that these whole-word poor readers place little reliance on the recoding skill. The above-mentioned means for the control condition, 4.5 for recoding poor readers and .9 for whole word poor readers are significantly different, $t(18) = 2.89$, one-tailed, replicating the finding of Experiment 1 that recoding poor readers depend more heavily on sound properties of words than do whole-word poor readers. Looking at the means for the concurrent vocalization condition, -.1 for recoding poor readers and .1 for whole-word poor readers, a non-significant difference is found $t(18) = 0.14$. This confirms the effectiveness of the concurrent vocalization manipulation in suppressing recoding and underlines the reliance of recoding poor readers on that recoding. This is so since under conditions of concurrent vocalization, recoding poor readers are deprived of their dominant skill and perform as poorly as whole-word poor readers who are also deprived of <u>their</u> dominant skill by being forced to deal with unfamiliar words.

The effect of concurrent vocalization on $S-\overline{S}$ scores for good readers was not large. Means of 3.6(2.88) in the control condition and 2.6(3.69) in the concurrent vocalizaton condition were not significantly different $t(9) = 0.61$. This finding reinforces the claim previously stated, namely that good readers find the concurrent vocalizaton task less interfering than recoding poor readers.

To conclude, evidence has been presented to show that:

a) under normal circumstances, recoding poor readers rely more heavily on a recoding skill than whole-word poor readers ($S-\overline{S}$ is greater for recoding poor readers in the control condition).

b) concurrent vocalization, interfering as it does with the recoding skill, causes greater interference among recoding poor readers than whole-word poor readers. This was shown both in an analysis of d' scores for the word-nonword decision, and $S-\overline{S}$ scores for the two types of nonwords. This result confirms the greater reliance of recoding poor readers on recoding to sound while reading.

Experiment 3

Introduction

The third experiment investigated a final question of interest concerning the difference found in Experiments 1 and 2 between recoding poor readers and whole-word poor readers in their reliance on recoding. As mentioned earlier, Kleiman (1975) distinguished between two uses of recoding. His lexical-access hypothesis asserts that recoding occurs prior to lexical access and may play some role in the access process and his working-memory hypothesis asserts that recoding occurs after lexical access and is used primarily to hold items for further processing. In Experiments 1 and 2, evidence is presented suggesting that recoding poor readers rely on recoding for lexical access and that whole-word poor readers do not use recoding for this purpose. These experiments concern themselves with Kleiman's lexical-access hypothesis since the decision task always involved one word at a time with no real constraints on the length of time the printed stimulus was available to the child. Under these circumstances, the role of working memory is minimal.

A question of interest is whether differences can be found between the two groups of poor readers in their reliance on recoding in a situation where lexical access is simplified and demands are imposed on working memory. Such a situation is provided by the short-term-memory task used by Conrad (1971). In this task, children were presented with two sets of 8 colored pictures. One set (the <u>homophone</u> set) comprised pictures of objects which had like-sounding names: rat, mat, hat, cat, bat, man, bag, tap, whereas the other set (<u>nonhomophone</u>) used pictures with the following names: girl, bus, train, spoon, fish, horse, clock and hand.

After appropriate practice, a complete set of eight pictures (alternating from homophone to nonhomophone from trial to trial) were laid face up and at once covered up. Then n cards drawn from a duplicate set were placed face up before a child and the experimenter named each of the cards, turning them over at the same time. The original set of eight cards was then uncovered and the child tried to match from memory the n cards face down to the eight cards now face up. The value of n was set for each child on the basis that for a given n, on the average of 50% correct matches occurred for the homophone set. The results of Conrad's (1971) experiment are shown in Table 11 which compares recall of homophone and nonhomophone sets for children with ages ranging from 3 to 11 yrs. At older ages, comparable to those of grade-3 children, nonhomophone items are more easily recalled than homophone items. This result parallels findings of Conrad (1963). In that study, adults read lists of words for immediate serial recall. Lists drawn from words consisting of homophones (e.g. horse, hoarse) showed poor recall when compared to word lists in which all words sounded differently.

The interpretation of these results favored by Conrad (1972) is that similar-sounding items are confusable in S.T.M. and that these older children and adults were relying on the sound properties of items for recall purposes, leading to problems with homophonic stimuli. As can be seen from Table 10, younger children (3-5 yrs) show no

Table 11

Percentage of Correctly Matched Cards (After Conrad [1971])

Mental age (years)	3-5	5-6	6-7	7-8	8-11
No. subjects	21	20	16	20	18
H set correct (%)	52.4	52.0	51.9	52.1	52.4
NonH set correct (%)	52.8	59.1	64.0	69.1	75.3
Mean no. items presented	3.22	3.8	4.1	4.4	5.9

difference in memory for homophonic and nonhomophonic sets. Conrad (1971) interprets this lack of a difference as revealing that younger children have not yet begun to rely on a sound-based code in S.T.M. and goes on to suggest that it is not until children begin to use the more effective sound-based code in S.T.M. that they are ready to learn to read.

This work of Conrad is interesting in that it provides a procedure which allows an examination of the hypothesis that recoding poor readers differ from whole-word poor readers not only in the use of recoding for lexical access but also in the use of recoding to promote efficiency in S.T.M. In addition, this work suggests an interesting hypothesis. If the use of recoding in S.T.M. must develop, then its development should be slower in some readers. Perhaps whole-word poor readers do not use a recoding skill because their S.T.M. does not yet rely on a sound-based code. If this were true, then the recoding skill would be difficult if not impossible to implement.

The current experiment used a procedure similar to that of Conrad to investigate the question of potential differences in the use of recoding in S.T.M. between recoding poor readers and whole-word poor readers. That is, the current experiment sought to establish whether recoding poor readers are better than whole-word poor readers in the use of sound-based properties of words for purposes other than lexical access. This corresponds to investigating Kleiman's (1975) working-memory hypothesis.

Method

Subjects. The three groups of readers defined in Study I participated.

Stimuli. Twenty colored drawings about the width of but slightly shorter than standard index cards were individually mounted on index cards. Duplicate sets of five pictures had like-sounding names (hat, cat, bat, man, fan) and in addition, duplicate sets of five pictures had different sounding names (ring, frog, bell, pie, nail). Pilot work on different children had previously established that five cards constituted a good memory load, avoiding ceiling and floor effects.

Procedure. Each child was seen individually in sessions lasting approximately 45 min. Children were initially shown each of the 10 different pictures once in random order and asked to name them. With the exception of two children who gave the response "cake" to the picture of a pie (and who were corrected), naming was effortless and errorless. A single practice trial then followed during which either the homophone set or the non-homophone set (whichever was to be used first in the experiment proper) was shuffled and laid out in a row in front of the child. The child was asked to name each card out loud as the experimenter pointed to it. After this, all five cards were turned over and the child was asked to "remember them". The duplicate set was then shuffled and laid out face up also in a row some distance from the first. The experimenter explained to the child that "this is a game in which you move these turned-over cards beside the picture so that they match". The experimenter demonstrated by moving a card over. The child was then encouraged to match all five cards. Once this was completed, the experimenter turned over the to-be-remembered cards and showed the child how many were correct. All children at this point showed an understanding of how the "game" worked.

Following this, sixteen trials each of the homophone and nonhomophone sets followed in two blocks with a short (2 min) break in between. Half of the children in each of the three groups received the homophone set first, half the non-homophone set. The experimenter recorded for each trial how many cards were correctly matched.

Results and Discussion

A preliminary analysis revealed that it made no difference if a child saw the homophone set or the nonhomophone set first; thus this variable will not be considered further. Raw data in the form of the total number of correct guesses out of 80 (5 x 16) for both the homophone and nonhomophone set formed the input into a 3 x 2 analysis of variance with the three types of reader as a between-subjects factor and the homophone - nonhomophone factor as a within-subjects factor. Results show that the type of reader was not significant, $F(2,17) < 1$, the difference between homophones and nonhomophones was significant, $F(1,37) = 27.5$, and the interaction was not significant, $F(2,37) < 1$. Quite simply, all three groups of readers show about equal differences between homophone and nonhomophone responses. Expressed in terms of proportion correct, recoding poor readers showed mean proportions of .54 and .65 respectively, $t(9) = 3.47$, one-tailed, whole-word poor readers showed mean proportions of .58 and .66 respectively $t(9) = 1.90$, one-tailed, and good readers showed mean proportions of .61 and .71 respectively, $t(9) = 2.68$, one-tailed. All three differences were significant.

The results of this experiment provide no support for the hypothesis that the two types of poor reader differ in the use of recoding for efficient use of S.T.M.. As well, no evidence was found that the poor readers differ from good readers in this ability (3). At first glance, the finding that poor readers who are not recoding to access word meaning nevertheless do so in order to hold items in S.T.M. just as efficiently as good readers may seem paradoxical. However, two considerations clarify the issue considerably.

First, an interesting experiment by Tzeng, Hung and Wang (1977) with Chinese readers is relevant. Chinese script, as is well known, is not alphabetic or syllabic but rather logographic. That is, a single character corresponds to a single morpheme; the whole pattern corresponds to a whole response. Presumably readers of Chinese do not have available a recoding skill for reading, having available only a whole-morpheme skill. Thus, recoding cannot occur before lexical access in reading Chinese. Tzeng et al. correctly point out that it has been assumed in the past that readers of Chinese must be able to read without speech recoding altogether and that this assumption has never been questioned. Based on Kleiman's distinction between recoding for lexical access and recoding for S.T.M. facilitation, Tzeng et al. show that recoding does occur for readers of Chinese, in situations where S.T.M. storage is required. In a first experiment, they show effects of phonemic similarity on short-term retention of lists of Chinese characters and in a second experiment they show that phonemic similarity also affected response latency in a sentence (printed in Chinese) judgment task.

Thus, it is not at all implausible for readers who use a whole-word skill in word recognition to rely nevertheless on recoding to hold identified words more effectively in S.T.M. This is true for readers of Chinese and seems to be true of the whole-word poor readers of the present experiment. A second consideration stems from the hypothesis suggested earlier to explain why whole-word poor readers lag behind recoding poor readers in the developmental shift to reliance on recoding in S.T.M. The results of this experiment suggest that by grade 3 even the whole-word poor readers have developed a reliance on recoding in S.T.M. but this does not rule out the hypothesis in question. It is not at all inconceivable that skill preferences could have been formed early in the process of learning to read. That is, a beginning reader in grade 1 who lags behind developmentally, who has not yet become proficient at recoding in S.T.M., may experience difficulties in acquiring the recoding skill and may as a consequence rely heavily on a whole-word skill. This preference may persist into grade 3 when the original source of the preference, an inability to recode effectively in S.T.M., has since finally disappeared albeit rather late relative to other readers. This hypothesis requires longitudinal study and will not be pursued experimentally here.

To conclude, the present experiment establishes that the use of recoding to facilitate S.T.M. storage is equally well developed in all three groups of readers (good, poor whole-word and poor recoding).

Experiment 4

Introduction

The previous three experiments have substantiated the claim that recoding poor readers and whole-word poor readers differ in the use of recoding to gain lexical access but not to facilitate S.T.M. The second difference between the recoding skills and the whole-word skill, namely the difference in reliance on morphemic vs. sub-morphemic units has not yet been substantiated. To recapitulate briefly, whole-word poor readers should depend more on the visual properties of words including whole-word shape and pattern than recoding poor readers. In this experiment, the second half of the Chinese-Phonecian diagnostic used by Baron and Strawson (1976) was used. This task, it will be recalled, involved presenting pairs comprised of words and their misspellings where both lead to the same pronunciation and asking subjects to choose between them. Some subjects were better at doing this than others. In this situation, only visual properties of words allow the two words to be discriminated.

Take for example, the pair 'BITE' and 'BIGHT'. A pure recoding skill would be able to generate a correct pronunciation for this pair since they are regular, but would be unable to discriminate between them. On the other hand, a pure whole-word skill would either fail to generate a pronunciation because the pair is unfamiliar or would generate a pronunciation because one member of the pair, presumably the word, triggers lexical access and thus a pronunciation. In the first case, a guess as to which word was real would have to be made but in the second case the correct choice should always be made. The prediction thus follows that if recoding poor readers and whole-word poor readers are presented with a list of such pairs where all pairs have regular pronunciations, then recoding poor readers should be good at generating pronunciations but poor at choosing the real word. Whole-word poor readers may not generate correct pronunciations as often, but when they do, it should be because the real word was familiar and hence easy to pick out. It was thus predicted that faced with choosing which of two stimuli - a word and a similar sounding nonword, whole-word readers should do better than recoding poor readers. This followed since only visual properties (relative familiarity) of the pairs allowed their discrimination.

Method

Subjects. Again, the 30 readers in three groups defined in Study 1 participated.

Stimuli. Thirty-two pairs of items were printed on 3 x 5 index cards as in Study 1 except with two members of a pair on one card. Each pair was made up of an English word and a nonword with the same pronunciation and for half of the pairs, the English word appeared on the left, for half it appeared on the right. Sixteen of the pairs were used in Experiments 1 and 2 and were thought to contain relatively unfamiliar items. Since it was feared that these items would be difficult for whole-word bad readers to deal with, a second set of sixteen pairs was added in which the real word member of each pair was a word all of these readers had likely seen before. A list of all 32 pairs can be found in Appendix 4.

Procedure. Children were seen individually for sessions lasting 20-30 min. At the beginning of a session, each child was reminded of the existence of nonwords. This was easy to do since by now each child had considerable experience with them. The child was then told that 32 pairs of words would be presented one at a time and that these words should be read aloud and then that the "real" word should be pointed at. Cards were presented individually and kept in view until the child read the words and then chose the English word. If a reading error was made, a choice was still required and then the child was corrected by the experimenter and required to choose again. Presentation speed was contingent solely upon the individual child.

Results and Discussion

The easy set was in fact too easy, with only a total of nine classification errors made by all readers combined. That is, only nine times out of 30 x 16 judgments was a nonword chosen. Apparently, this particular set of English words is well-known to grade-3 readers. For this reason, the easy set will no longer be considered.

On the hard set, good readers made only 7 classification errors out of a possible 10 x 16 judgments and no individual poor reader made fewer errors than the single good reader who made two. Thus good reader performance is superior to poor reader performance and will not be discussed further.

Looking at initial classifications irrespective of correctness of pronunciation, whole-word poor readers made more errors than recoding poor readers $t(18) = 2.23$, two-tailed. Mean error proportions were .27(.09) and .20(.06) respectively. But as expected, whole-word poor readers generated incorrect pronunciations for more of word pairs (4.6/10 per individual) than did recoding poor readers (0.8/10 per individual). When classifications were analyzed only for those pairs where a correct pronunciation was generated, whole-word poor readers made fewer classificaton errors than did recoding poor readers although not significantly so, $\underline{t}(18) = 0.83$. Mean proportions were .17(.12) and .20(.06) respectively.

Thus, as predicted, when only pairs correctly read are considered, whole-word poor readers are more accurate at picking out the English word. Unfortunately, the effect is not significant. A likely explanation is that in the difficult set, only four sound contrasts were used. Thus, four pairs of items were based on the same contrast. Of these four pairs, the English word was spelled one way in two of them and the other way in the other two. For example, four of the stimulus pairs from the hard set were 'BITE-BIGHT', 'KITE-KIGHT', 'BRIGHT-BRITE' and 'TIGHT-TITE'.

As mentioned earlier, Glushko and Rumelhart (1976) have presented evidence that unfamiliar letter strings may be pronounced by partial analogy with known words and in the introduction it was suggested that readers who use a whole-word skill may still be able to read unfamiliar strings through the use of partial analogy. If the whole-word poor readers in fact do use partial analogies to generate pronunciations, then the hard list was a good place to do it since the same patterns came up over and over again. Knowing the real word in one of the four pairs but not the others could then easily lead to analogies being drawn from unknown pairs to known pairs. Thus, if a whole-word poor reader knew the word 'BITE' from previous experience, then the pair 'BITE-BIGHT' would be correctly pronounced and the English word correctly chosen. But now if the unfamiliar pair 'TIGHT-TITE' were treated by partial analogy with 'BITE-BIGHT', then a correct pronunciation would result along with the incorrect choice of 'TITE' as the English word. Thus, the corrected error rate of 17% for whole-word poor reader may be an overestimate, due to a number of partial analogy generated errors.

It seems, therefore, that a test of the hypothesis investigated in this experiment awaits a set of word pairs difficult enough to generate classification errors and constructed to take the possibility of partial analogy-generated pronunciations into account.

Experiment 5

Introduction

While Experiment 4 provided no solid evidence of a greater reliance by whole-word poor readers on visual properties of words, a manipulation used by Baron and Strawson (1976) did find such evidence. Adult readers were separated into two groups, namely Chinese (whole-word readers) and Phonecians (recoding readers), by diagnostics discussed in Experiments 1 and 4. Following this, lists of words printed either in normal lower case form or in alternating upper-case and lower-case letters were presented. The time taken to read each list was recorded as the dependent variable. As might be expected, lists printed in the unfamiliar alternating format took longer to read, but the finding of interest for present purposes was that Chinese were disrupted more than Phonecians. Baron and Strawson's (1976) interpretation of this finding is that whole-word readers rely more heavily on word shape as a cue to word recognition than do recoding readers. That is, Chinese use large units more often than do Phonecians, who rely on small units. By printing words with letters in alternating case, word shape and other large-unit clues are disrupted, thus presumably disrupting the performance of whole-word readers more. The current experiment used this technique to address the hypothesis that the whole-word poor readers of the present work rely more heavily on large-unit visual information. Thus, the prediction was that whole-word poor readers would be disrupted more than recoding poor readers when reading words printed in alternating case.

Method

Subjects. Again, the thirty readers isolated in Study 1 participated.

Stimuli. The concern in construction of the stimulus set was to minimize errors in the control condition. To this end, 64 words were selected from a set of norms circulated among the teachers of these children. These words were all words the children have been formally exposed to and as such should have been relatively familiar. The 64 words were randomly divided into two sets, A and B, which are presented in Appendix 5. Each word was printed, as in previous experiments, singly on standard index cards. This was done twice for each word, once in lower case letters and once in alternating upper case and lower case letters. A randomly chosen half of the words in each set A and B began with an upper case letter and half began with a lower case letter.

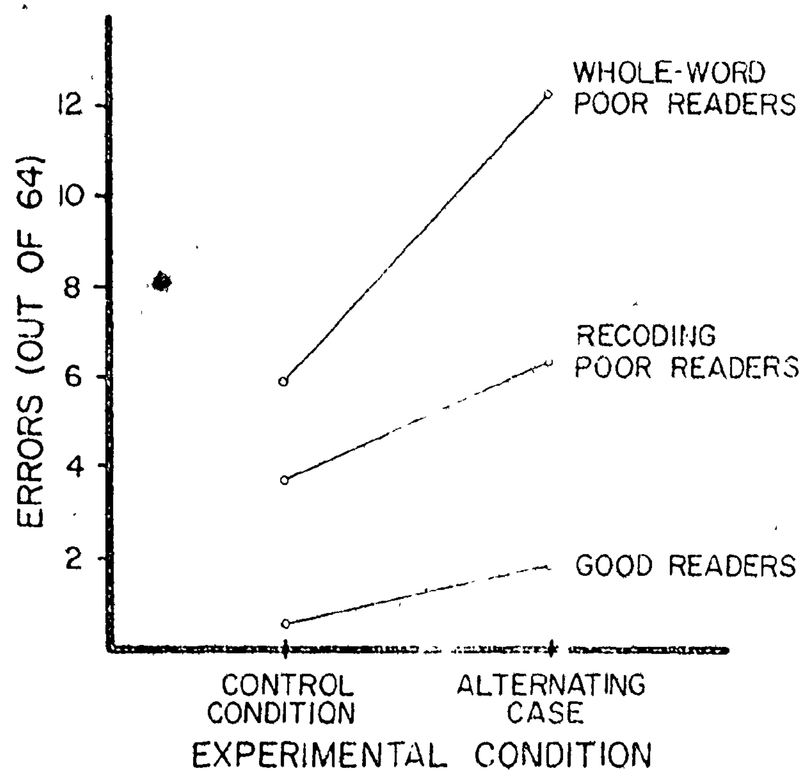
Procedure. Each child participated on an individual basis, in sessions requiring 30-45 min. Every child read a control set first and then an alternating set. If set A was read in a control condition, then set B was read in the alternating condition and vice versa. Half of the children in each group began with set A, half with set B. Stimulus cards were presented one at a time as in previous experiments and kept in full view until a response was made. Presentation rates were determined by each child. Before beginning, children were simply asked to read aloud 32 words. Before beginning the alternating set, children were told that "this set of 32 words is printed funny but you can read them anyway."

Results and Discussion

The dependent variable of interest was the number of errors made by children in the three reading groups for the control and alternating conditions. A two-way analysis of variance revealed a significant difference between groups in the overall number of errors, $F(2,2) = 19.0$, a significant effect of the alternating-case manipulation, $F(1,2) = 53.2$, and a significant groups by alternative case interaction, $F(2,27) = 8.98$. The data are plotted in Figure 8. Post-hoc *t*-tests reveal that overall, good readers made fewer errors than recoding poor readers and recoding poor readers made fewer errors than whole-word poor readers. The significant difference between reading groups replicated differences found earlier. The significant effect of alternating case can be elucidated by assessing the interference effect separately for each group. Mean errors were .5(.97) and 1.7(1.49) for good readers, $t(9) = 3.67$, 2.8(2.25) and 6.2(2.74) for recoding poor readers, $t(9) = 3.96$, and 5.8(3.79) and 12.2(5.55) for whole-word poor readers, $t(9) = 5.36$. All three differences were significant. That is, the alternating-case manipulation adversely affected all three groups. The significant interaction, however, indicates that all three groups did not suffer equivalent interference.

In order to assess directly the primary hypothesis of this experiment, namely that whole-word poor readers would experience greater interference from the alternating-case condition than recoding poor readers, a difference score was defined. This score was the difference between the number of errors in the alternating case

FIGURE 8


WHOLE-WORD POOR READERS
RECODING POOR READERS
GOOD READERS
ERRORS (OUT OF 64)
12
10
8
6
4
2
CONTROL CONDITION
ALTERNATING CASE
EXPERIMENTAL CONDITION

condition and the number of errors in the control condition for each group. The average difference was 3.4(2.72) for recoding poor readers, and 6.4(3.78) for whole-word poor readers. These values were found to be significantly different, $t(18) = 2.04$, one-tailed, confirming the hypothesis. Thus, evidence can be found suggesting that whole-word poor readers rely more on visual properties of printed words, namely word-shape, than do recoding poor readers.

Study 2

Introduction

The empirical work reported to this point supports the notion that poor readers lack the flexibility to use one or the other word identification skill. In the work to follow the focus was on the second issue mentioned in the general discussion - namely the use of higher-order context to aid in word identification. This study investigated poor reader's ability to use a particular kind of context.

This information was category information. Recall the findings of Mitterer (1977) that response latency to make a lexical decision was speeded if appropriate category information was supplied before that decision was required. Thus, the target item 'DOG' was judged to be a word faster if it was shortly preceded by 'ANIMAL' than by a neutral stimulus, 'XXXX'. In this case contextual information, namely category information is used to facilitate processing.

The current study used a variant of this priming technique to investigate the ability of poor readers to use category information to facilitate word processing. In accord with tentative conclusions drawn in the introduction, it was expected that poor readers would manifest some level of ability to use context especially when it is as well defined as in the priming paradigm. That is, these poor readers were expected to improve their performance in word identification when supporting context was introduced.

A second purpose of this study was to investigate the possiblity that recoding poor readers are less able than whole-word poor readers to use available contextual information as an aid in word processing. This hypothesis arose in conversations with teachers of reading who often suggested that children who rely too heavily on sounding out words tend to be "word-plodders" who move tediously from one word to the next. On this account, such readers may be expected to benefit little from contextual manipulations. A prediction derived from these conversations was that recoding poor readers should show less improvement due to introduction of context than whole-word poor readers.

Method

Subjects. The three groups of readers defined in Study 1 participated.

Stimuli. The category norms of Battig and Montague (1969) were used in item selection. Five categories were first chosen on the grounds that they were quite concrete and familiar to children. The categories chosen were animals (four-footed), fruit, furniture, clothing, and body parts. Fourteen items were chosen from each category such that 6 were "easy" and 8 were "hard", where easy and hard refer to the experimenter's judgment of reading difficulty. Wherever possible, the words chosen were more common category members. The full set of 70 words is presented in Appendix 6. Each word was printed as in Study 1 on a standard index card, four times for each word. The 40 "hardest" items were split up into two sets, A and B such that each set of 20 items had 4 items from each category.

Each child was presented with 14 lists of 10 words per list. The first five lists were all unordered with respect to category and were composed of the 30 easy words and one of the hard sets. Each list contained two items from each of the five categories and was constructed so that at least two non-category items separated each of the pairs of category items. The next two lists were made up of the remaining set of hard items and were similar in composition to the first five lists. These seven lists thus exhausted the original pool of 70 words.

The next five lists were composed by re-ordering the words in the first five lists so that the ten items of each category were brought together in a single list with the six easy items first and the four hard items last for each of the five categories. Finally, the last two lists used the items in lists six and seven and re-ordered those items while observing the same constraints as lists six and seven.

To sum up, experimental lists 1 to 5 included 30 easy and 20 hard words in an essentially random order. The category membership of words immediately prior to any given word in these lists gave no useful information about that word. Lists 8 to 12 contained the same fifty items rearranged into categories. Now the category membership of a target item was cued by the category membership of all previous words in the list.

Lists 6 and 7 were rearranged in lists 13 and 14 and in neither case was any useful category information presented. These two lists thus formed a control condition to check on the effects of simple repetition. Finally, two different sets of lists were formed by using hard set A in the experimental lists and hard set B in the control lists in one and reversing the two hard sets in the other. Thus, the hard items of each set appeared two times, once in random and then categorized lists and once, repeated in random lists.

Procedure. Each child participated individually in a session requiring about 45 min to complete. Half of the children in each group of readers read one set of lists, half read the other set of lists. The order of lists and of words within each list was fixed for each of the two sets of lists. The fixed order of lists was: five experimental random lists, two control random lists, five experimental categorized lists and two control random lists.

At the beginning of the session, the child was simply asked to read 14 lists of 10 words per list the same way as before. Again items were presented as previously. Before each of the five experimental categorized lists, children were informed of the category in question: e.g. "All of the words in this list are names of different kinds of fruit".

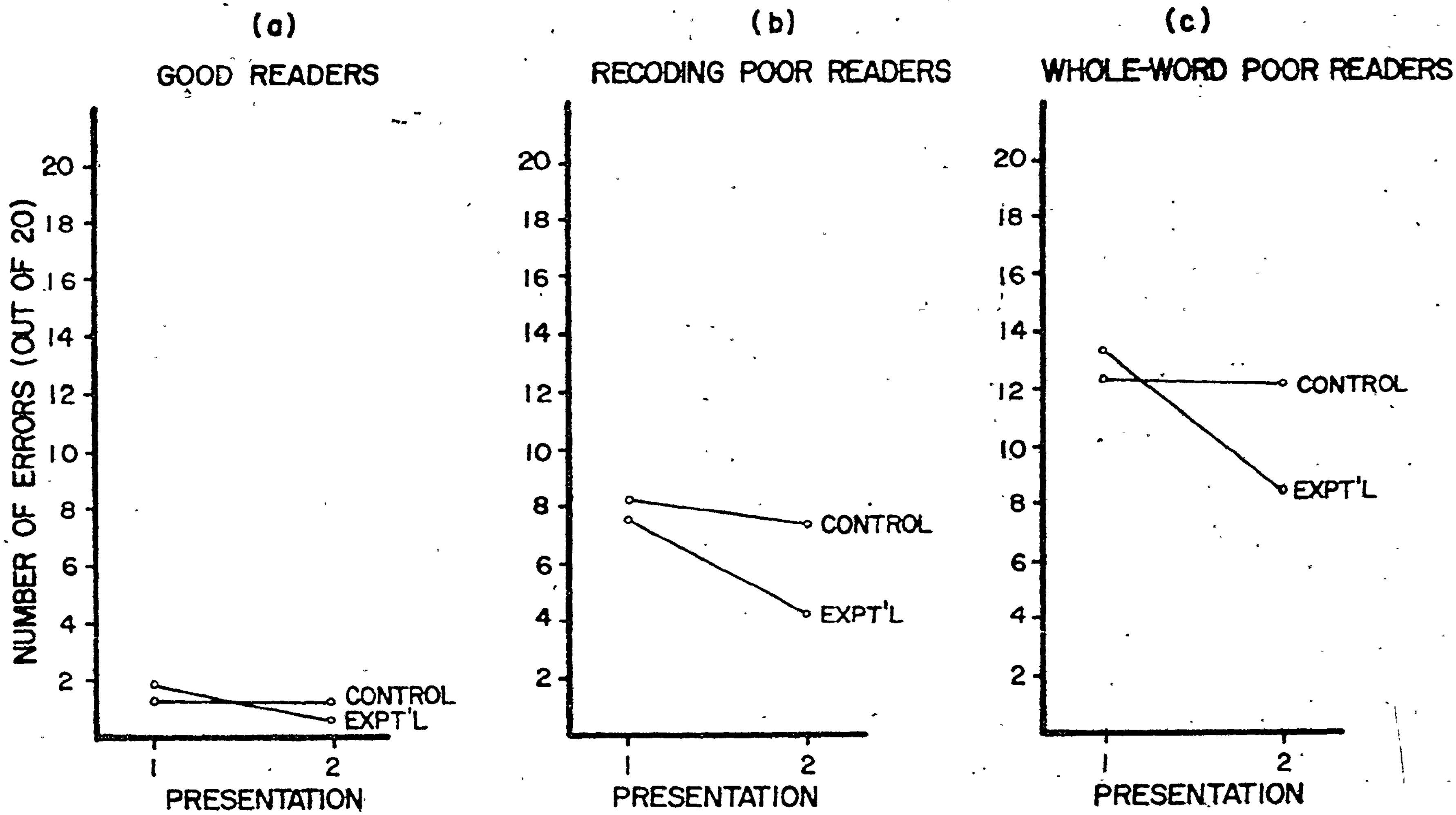
Record was kept of which words were read correctly and errors were transcribed as they occurred to allow subsequent analysis. Also, response latency was recorded as outlined in Experiment 2.

Results and Discussion

Errors. The first analysis of interest concerns the number of errors made by each of the three groups of readers on the hard items. By comparing the number of errors (out of 20) made in the two control conditions (lists 6 and 7 vs lists 13 and 14), an index of the effects of repetition can be obtained. That is, if fewer errors were made on the control lists on their second presentation, then the conclusion can be drawn that having two chances to read a word is better than having only one chance. Since there were no time limitations imposed during the initial attempt to read these words, there was no reason to suspect that performance should improve on a subsequent attempt. The difference in the number of errors made on the hard words in the two experimental conditions (lists 1 to 5 vs lists 8 to 12) will yield an index of the effects of category information. That is, if fewer errors are made the second time these words are encountered this may be because the category information which is available the second time around is used as an aid to word recognition. Of course, this difference may also be due solely to repetition, but a comparison between the experimental and control conditions allows this possibility to be evaluated.

Bearing these considerations in mind, the good readers will be dealt with first. In part (a) of Figure 9 are plotted the number of errors made in each of the four conditions (two experimental, two control) for the good readers. It should be noted that error rates overall are extremely low, at 9% or less. Thus performance is so good even on items presented the first time in random contexts that little improvement due to the contextual manipulation can occur. In spite of this, evidence that these good readers use context comes from the significant decrease in errors in the experimental condition with error rates of 1.80(1.69) and .60(.70) respectively, $\underline{t}(9) = 2.34$, and the

FIGURE 9


(a)
GOOD READERS
(b)
RECODING POOR READERS
(c)
WHOLE-WORD POOR READERS
NUMBER OF ERRORS (OUT OF 20)
20
18
16
14
12
10
8
6
4
2
CONTROL
EXPT'L
1
2
PRESENTATION

non-significant decrease in errors in the control condition with error rates of 1.30(1.49) and 1.20(1.81) respectively $t(9) = 0.36$.

This evidence for context use in good readers is statistically marginal since in a two-way analysis of variance with repetition as one factor and experimental vs control items as the other, the interaction effect just failed to reach significance, $F(1,18) = 3.12$, $p = .09$. Because of the low number of errors made by good readers, it is not reasonable to compare the good readers and the poor reading groups except to note the overall performance superiority of the good readers.

Data for the recoding poor readers is plotted in part (b) of Figure 9. In a two-way analysis of variance with repetition and the experimental vs control items as factors, a significant interaction was obtained, $F(1,18) = 5.61$. This can only mean that the decrease in error rate on the second occurrence of items is greater in the experimental condition than in the control condition. This constitutes evidence that recoding poor readers can use category information to aid in word recognition. There is a significant decrease in error rates with repetition for the experimental items, with mean of 7.6(3.72) and 4.2(3.08) respectively, $t(9) = 3.36$. Surprisingly, the small difference obtained for the control items, 8.2(4.92) and 7.2(5.01), respectively, is also significant, $t(9) = 3.87$.

Whole-word poor readers also show evidence of an ability to use a category context to aid in word identification as can be seen from part (c) of Figure 9. In a two-way analysis of variance, the interaction of repetition with the experimental-control factor again is significant $F(1,18) = 27.6$. While there is a significant decrease in errors in the experimental condition with means of 13.3(3.95) and 8.5(5.87) respectively $\underline{t}(9) = 5.80$. there is no corresponding decrease in the control condition with means of 12.3(4.55) and 12.2(5.20) respectively, $\underline{t}(9) = 0.19$. To sum up, all three groups of readers evidence an ability to use contextual information (category membership) as an aid in word identification as indexed by error rates.

The second question of interest concerns the possibility that whole-word poor readers may show <u>greater</u> ability to use contextual information than recoding poor readers. To assess this possibility, difference scores were defined as the difference in number of errors on first and second presentation for experimental (D_E) and control (D_C) conditions separately. A two-way ANOVA with the two groups of poor readers as a between-subjects factor and D_E vs D_C as a within-subjects factor was used to evaluate this possibility. The only aspect of this analysis of any relevance was the failure to obtain a significant interaction, $\underline{F}(1,18) = 2.18$. Since the magnitude of the difference between D_E and D_C is a direct index of the ability to use context, a significant interaction showing a greater difference between D_E and D_C for whole-word poor readers than for recoding poor readers would be required to substantiate the claim of differential ability to use context. Thus, although the results tend in the expected direction, such a claim cannot be upheld.

To sum up briefly to this point:

1) all three groups of readers show evidence of using contextual (category) information in improving the probability of word identification.

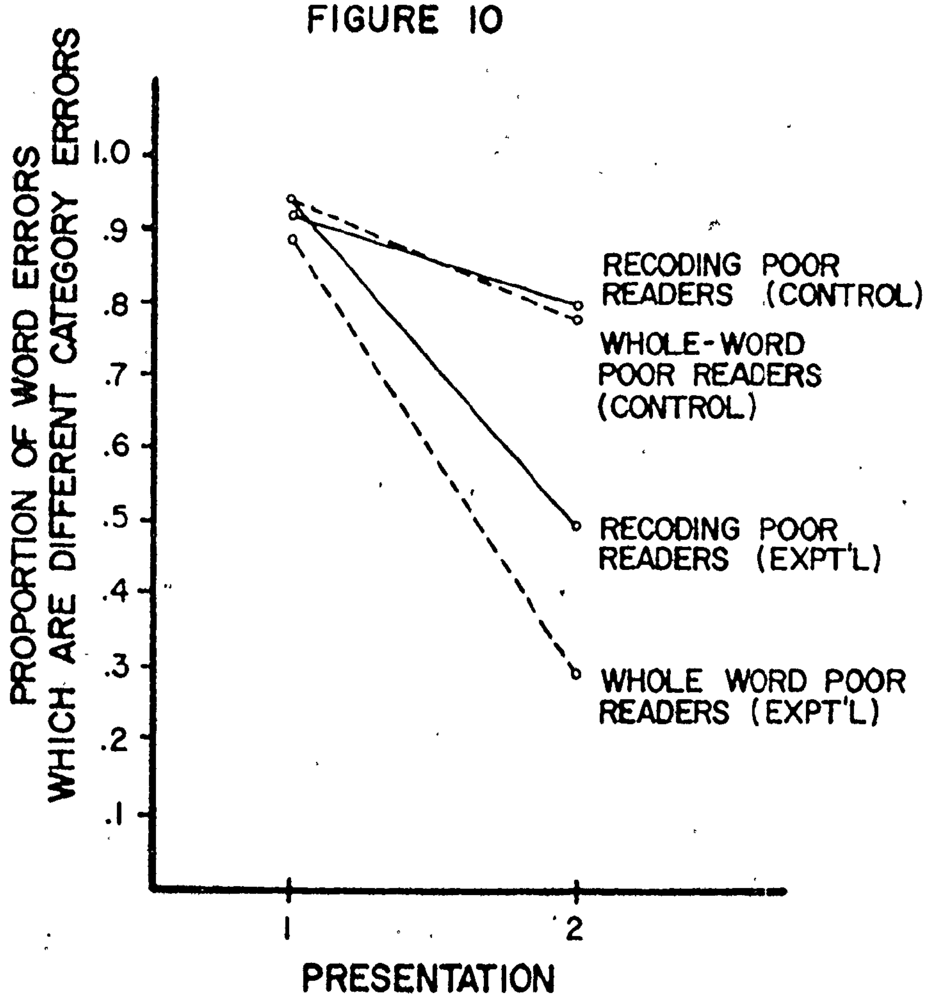
2) support for the possibility that whole-word poor readers use such context more than recoding poor readers was not forthcoming.

3) these data did not allow an evaluation of the possibility that good readers are more efficient users of contextual information than poor readers, primarily due to the performance ceiling encountered by good readers. It is possible that any attempt to undertake this comparison will be fruitless since such large differences in word identification ability of necessity will confound any such comparison.

Error Types. A second analysis of interest concerns the types of errors which are generated without contextual information as compared to with contextual information. (Since so few errors were generated by good readers, they will not be considered further.) First consider only those errors which were themselves words. Each such error was compared with the stimulus word to which it was a response and was classified as being from the same category or a different category from that stimulus word. Figure 10 plots the proportion of word errors which are different category errors for both kinds of poor readers, for experimental vs control condition and for first and second presentation.

The results for the control condition were analyzed by a two-way analysis of variance with reader types as a between-subjects factor and repetition as a within-subjects factor. In this analysis, none of the F ratio's was significant. The four means were .94(.16) and .77(.29) for whole-word poor readers and .92(.13) and .79(.39) for recoding poor readers. This pattern of results is easy to understand.

FIGURE 10


PROPORTION OF WORD ERRORS
WHICH ARE DIFFERENT CATEGORY ERRORS
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
RECODING POOR READERS (CONTROL)
WHOLE-WORD POOR READERS (CONTROL)
RECODING POOR READERS (EXPT'L)
WHOLE WORD POOR READERS (EXPT'L)
1
2
PRESENTATION

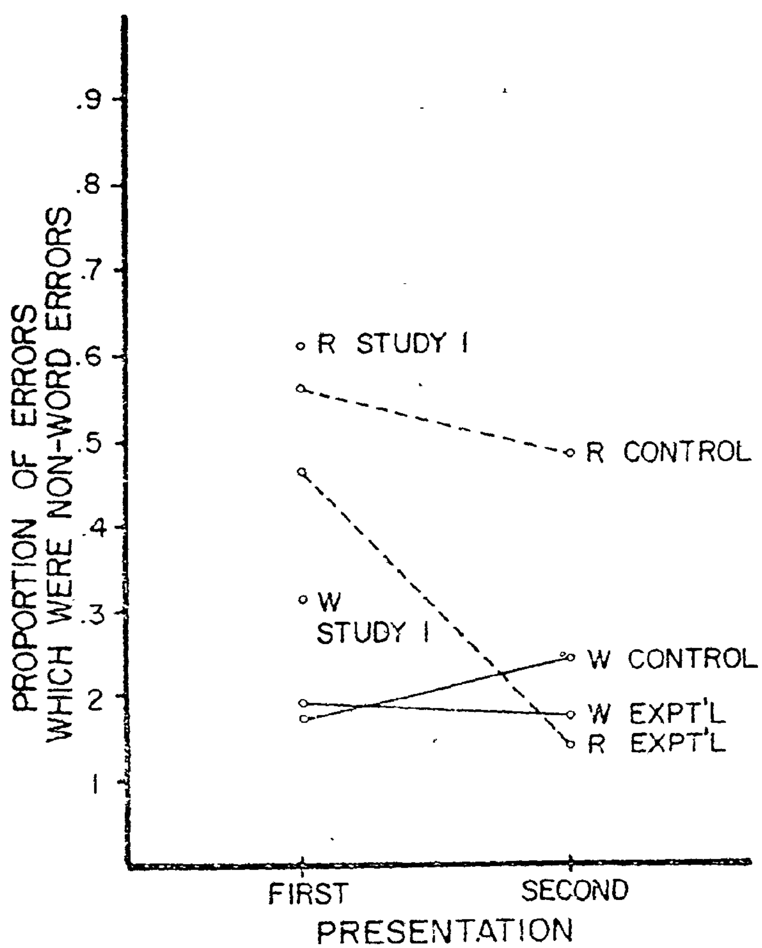
On the first presentation of these words, no useful category information is available to either type of poor reader and another word from the same category is unlikely to occur as a response to any particular item. Thus the likelihood of a different category response is quite high, as it was (92% and 94%). On the second encounter, no explicit category information is present either, but children are likely to have become aware of <u>which</u> five categories are being used in the experiment. This knowledge cannot lead, for either type of poor reader, to better than a 20% chance of guessing an item of the same category (as the target item). Thus, the rate at which different category items are guessed should approximate 80% as it did (77% and 79%).

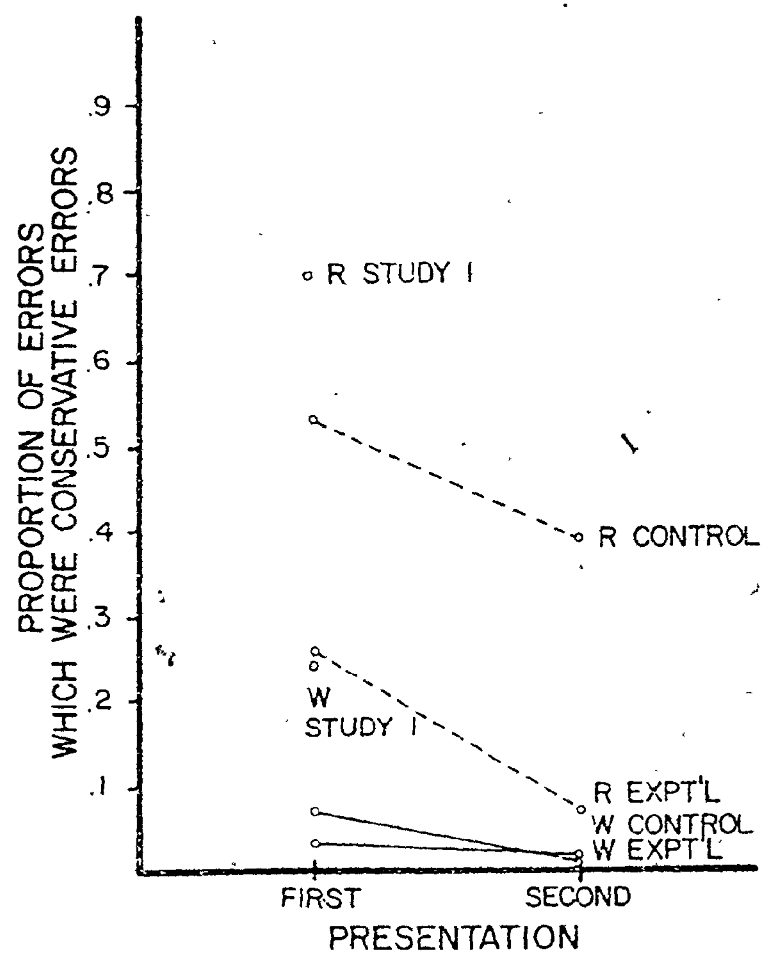
The results for the experimental condition were also analysed by a two-way analysis of variance with reader type as a between-subjects factor and repetition as a within-subjects factor. Again the reader type factor was not significant, $\underline{F}(1,18) = 1.86$ nor was the interaction, $\underline{F}(18,18) < 1$. However, the repetition effect was significant, $\underline{F}(1,18) = 35.6$. This finding coupled with the non-significant effect of repetition in the control conditions allows the inference that category information is used to guide responses even when those responses are errors. Actual means were .88(.08) and .29(.36) for whole-word poor readers and .94(.09) and .49(.44) for recoding poor readers respectively. This means that when a category context is available, both types of poor reader are able to use that contextual information to constrain their guesses on over 50% of all guesses (71% and 51%).

In a second analysis, errors were categorized as word or nonword errors and as conservative or liberal errors as in Study 1. Recall that conservative errors are those in which each letter in a word is given a sound value, although incorrect. In order to increase the number of errors available for this analysis, all 70 experimental items were considered, including the 20 control items. Figure 11 shows the proportion of nonword errors for both groups of poor readers for two repetitions of items with experimental and control items plotted separately. Included as a comparison are these values from Study 1. As can be seen, the finding of Study 1, namely that whole-word poor readers make proportionately fewer nonword errors than recoding poor readers is here replicated on the first presentation of items in Study 2. Two analyses of interest were performed, one on the control data, one on the experimental data. First, a two-way analysis of variance the two types of poor readers as a between-subjects factor and repetition as a within-subjects factor for control items confirms the Study 1 finding that whole-word poor readers make proportionately fewer nonword errors than recoding poor readers since the reader type factor was significant, $\underline{F}(1,18) = 9.16$. The main effect of repetition was not significant, $\underline{F}(1,18) < 1$, and the interaction was not significant, $\underline{F}(1,18) = 1.36$. These results allow the inference that repetition *per se* does not affect the proportion of nonword errors generated in this task.

Quite simply, these results re-confirm the finding of Study 1 that when random-word lists are being read, recoding poor readers'

FIGURE II





R = RECODING POOR READERS
W = WHOLE-WORD POOR READERS

errors are nonword errors more often than whole-word poor readers' errors.

A two-way analysis of variance on data from the experimental condition reveals a different pattern which can be interpreted as being due to the effects of category context. The finding of importance here is that of an interaction between type of reader and repetition, $F(1,18) = 9.49$. This result can only mean that the difference in the proportion of nonword errors which distinguishes the types of readers disappears when category context cues are available. On the first presentation, with proportions of .46(.21) and .19(.14) for recoding poor readers and whole-word poor readers respectively; the significant difference found twice previously was replicated, $t(18) = 3.42$. Recall that on this first presentation, no contextual information is available. When the same items are read in a category context, the difference with means of .14(.19) and .17(.18) respectively, is not significant, $t(18) = 0.20$. Thus, when words are read in a category context, the two types of poor readers can no longer be distinguished on the basis of the proportion of word as opposed to nonword errors which they generate. Furthermore, it appears that it is the recoding poor readers who show the greater change as a function of category information since the means for them (being .46 and .14) are significantly different, $t(9) = 4.47$, while the difference in whole-word poor readers (means of .19 and .17) are not significantly different, $t(9) = 0.20$.

In the second part of Figure 11 can be found the proportion of <u>conservative</u> errors for both types of reader for two repetitions with experimental and control items plotted separately. Again, values from Study 1 are included as a comparison. Again, analyses on control and experimental data were carried out.

A two-way analysis of variance on data from the control condition revealed a significant difference between the two groups of readers, $\underline{F}(1,18) = 12.8$, which means the finding of Study 1 that whole-word poor readers produce fewer conservative errors than recoding poor readers has been replicated. Surprisingly, the effect of repetition is significant, $\underline{F}(1,18) = 5.23$, indicating that with more experience in this situation, both types of reader increase the proportion of liberal errors which they emit. The finding of a significant effect of repetition indicates a need for caution in interpreting the results of the experimental condition.

A two-way analysis of variance for the experimental condition was not undertaken since no whole-word poor reader produced any conservative errors on the second presentation (i.e., when items were presented in context). Thus, this condition yields zero variance and cannot be sensibly tested against any other. Only two possible comparisons can be made. First, recoding poor readers make fewer conservative errors on the second presentation than on the first with means of .26(.24) and .07(.16) respectively, $\underline{t}(9) = 2.80$. Second, whole-word poor readers make fewer conservative errors than do recoding poor readers on the first presentation with means of .07(.08) and .26(.24) respectively, $\underline{t}(18) = 2.41$.

These two findings parallel those for the nonword errors discussed previously. Whole-word poor readers generate fewer conservative errors than recoding poor readers when random word lists are read and this difference diminishes when context is introduced primarily because of the change in the proportion of conservative errors in recoding poor readers. Of course, the results from the control condition mean that repetition alone, independent of context effects, could account for some of these results.

The results of this study can be summarized as follows: both types of poor reader are able to use category information to reduce the number of errors in word recognition. No statistical evidence of a difference between groups was found. Further, both types of poor reader use contextual information to guide guesses when errors occur. Again no statistical evidence of a difference between the types of poor reader was found. Thus, category information plays a significant role for both types of poor reader in guiding their responses to difficult words.

Finally, analyses of errors as conservative - liberal and word-nonword provide replications of results found in Study 1 when random word lists are examined. In contrast to this, these differences are generally eliminated when a category context is introduced. Thus, the two types of poor reader do not seem to differ in ability to use category context as an aid in word recognition and this ability to use such information predominates over the individual preferred word recognition strategies.

Study 3

Introduction

The findings of Study 2 concerning the ability of the two groups of poor readers to use context were obtained in a fairly atypical situation, that of highly structured categorized lists. It seemed desirable to examine a more 'normal' reading situation to see if the findings of Study 2 generalized. To this end, a set of paragraphs was presented to readers with the understanding that questions about the meaning of those paragraphs would be asked. Thus, short segments of connected text were read for meaning, a situation that more closely approximates 'normal' reading circumstances.

In this study, some paragraphs were relatively easy and some were relatively hard for these poor readers. It was hypothesized that in easy stories, context use would be efficient. This means that the poor readers should show evidence of this use and that, as found in Study 2, the measures which discriminate the two groups of poor readers should be relatively less effective.

In contrast, passages which are sufficiently hard to read should yield less understanding. Thus, less evidence for context use should be found than for easy passages. Also less contextual information should be available to override the single-word identification skills of these poor readers. Thus, the measures of these skills as established in Study 1 and Study 2 should discriminate the two groups of poor readers better in the hard than in easy passages. To summarize, the difference between random word lists and categorized word lists in Study 2 should be paralleled by the difference between hard paragraphs and easy paragraphs in the current study. The basic idea is that hard-to-read paragraphs, when difficult enough, functionally become word lists.

Method

Subjects. The three groups of readers isolated in Study 1 participated.

Stimuli. Six passages were obtained from Gray's oral reading test. These passages are scaled in terms of difficulty ranging from pre-primer, and level 1 to level 5. As can be seen from Appendix 7, which lists each story, the difference in difficulty between passages is lexical, syntactic and semantic in nature. Each passage had associated with it a set of four questions about that passage (to be found in Appendix 8). Stories were printed on ordinary wide-lined paper with capitals being a full line high and lower-case letters being half that height. Every second line was left blank, resulting in a highly legible text. Each story was printed on a separate page.

Procedure. Children participated individually in sessions requiring 10-20 mins. Each child was simply told that six stories were to be read aloud and that four questions about each story would be asked immediately following the completion of each story. The reading of each story was tape-recorded as in Study 1 and the time taken to read each story was obtained. No assistance was offerred while the stories were being read; all feedback was unconditional and positive.

Results and Discussion

Story Difficulty. The first set of analyses concerns the overall difficulty of the six stories as revealed in several measures. First, the total time to read a story was divided by the number of words in that story to obtain a rough measure of reading rate. In Figure 12 can be found plotted mean reading rates for each of the six stories separately for each group of readers. Good readers will again be treated separately from poor readers. These good readers begin to slow down only at the level 5 story, which is reasonable since their reading scores average above level 4. In contrast, the poor readers begin to slow down at level 2, again consistent with their reading scores which average just below level 2. A 2 x 6 analysis of variance with poor reader type as a between-subjects factor and story difficulty as a within-subjects factor revealed only a significant main effect of story difficulty, $F(5,50) = 18.7$. This result confirms that the two groups of poor readers do not differ in reading times on these passages (a result similar to that of Study 1) and that these 6 passages are indeed scaleable in terms of reading difficulty as indexed by reading times.

Second, the mean number of comprehension questions correctly answered was calculated for each group of readers on each passage separately and may be found plotted in Figure 13. The results parallel those of the previous analysis on reading rates. That is, good readers show lower scores primarily on the level 5 passage while the performance of the two groups of poor readers drops earlier, at about level 3. A 2 x 6 analysis of variance on poor readers only reveals a

FIGURE 12

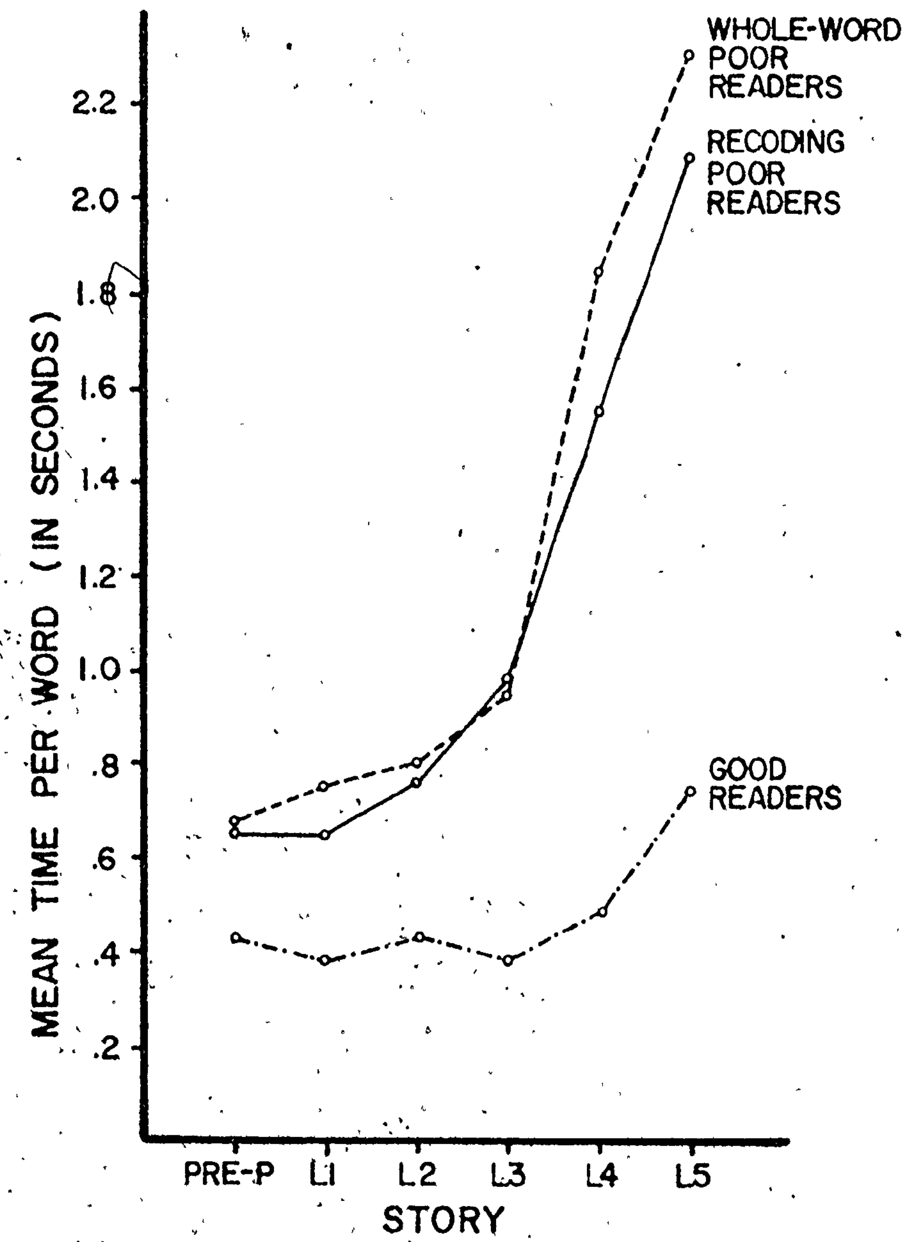
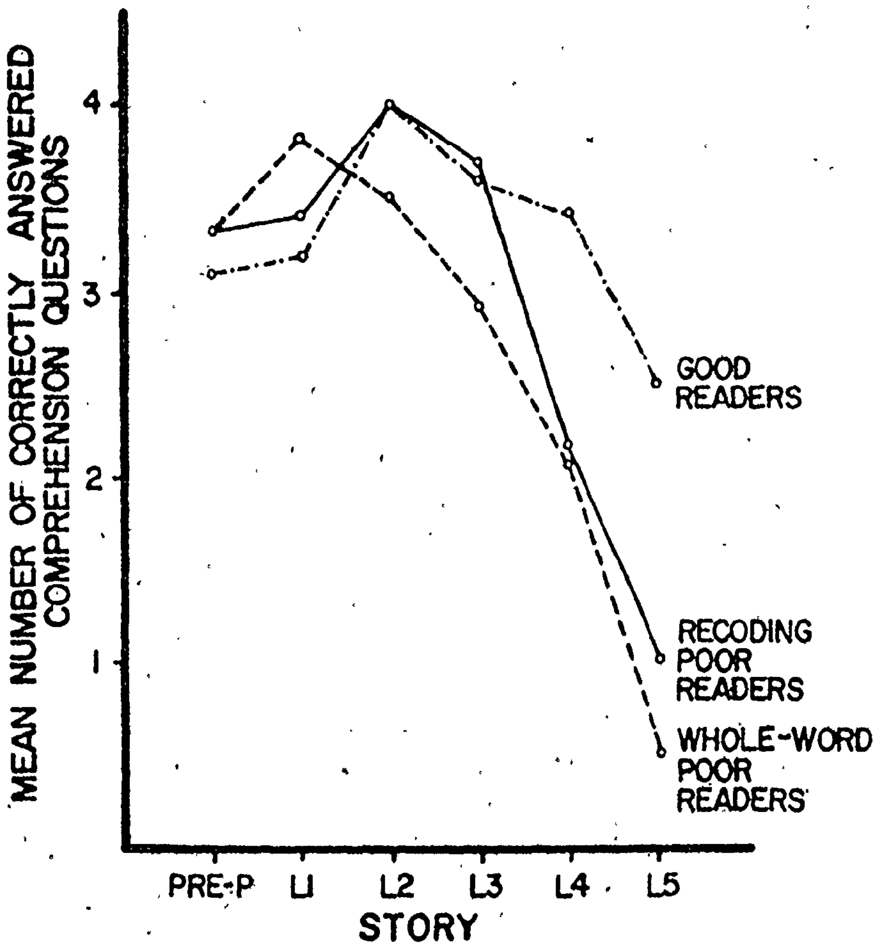

WHOLE-WORD POOR READERS
RECODING POOR READERS
GOOD READERS
MEAN TIME PER WORD (IN SECONDS)
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
PRE-P
L1
L2
L3
L4
L5
STORY

FIGURE 13



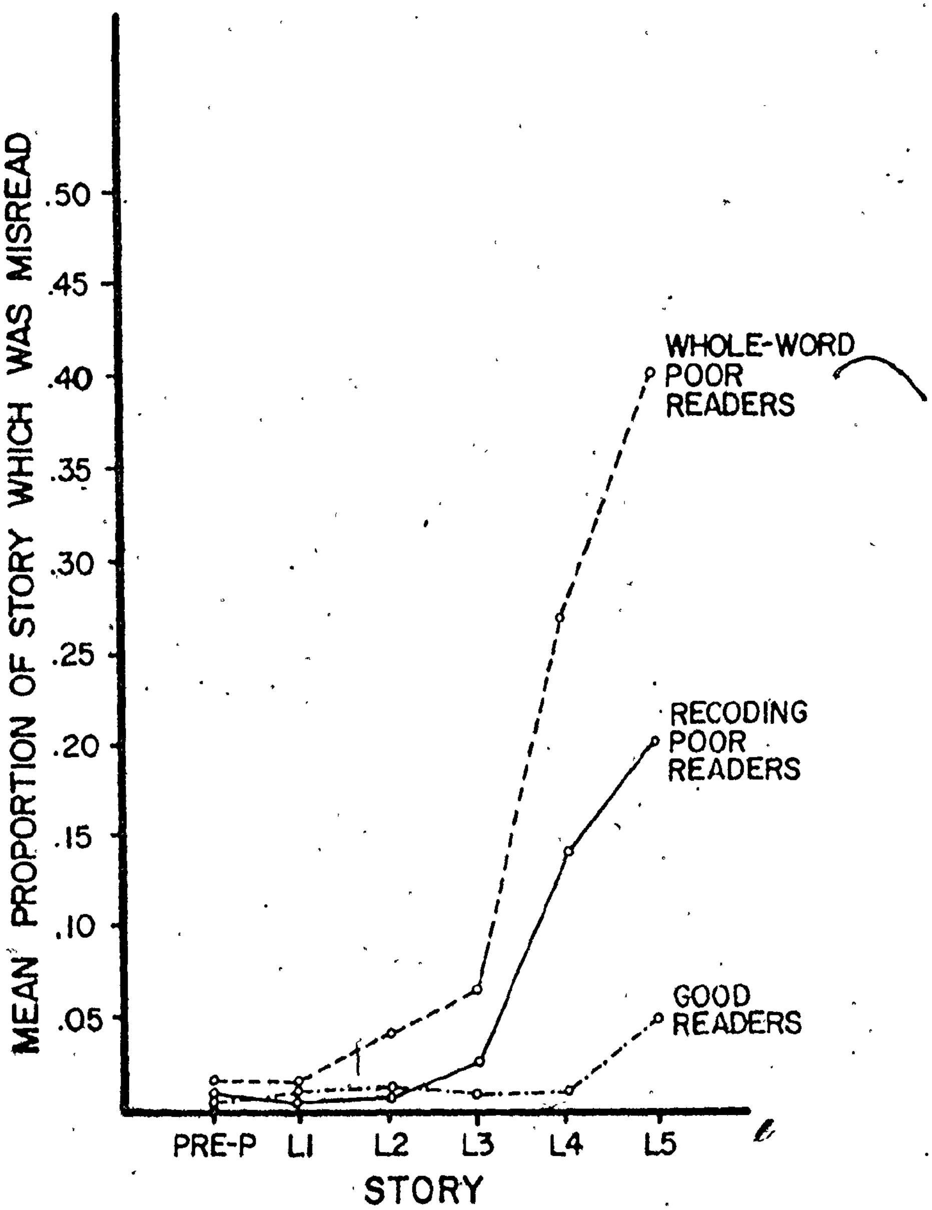
MEAN NUMBER OF CORRECTLY ANSWERED COMPREHENSION QUESTIONS
4
3
2
1
GOOD READERS
RECODING POOR READERS
WHOLE-WORD POOR READERS
PRE-P
L1
L2
L3
L4
L5
STORY

significant effect of story difficulty, $F(5,50) = 18.7$, as well as a significant effect of reader type, $F(1,58) = 7.15$, but no interaction, $F(5,50) < 1$. The significant effect of story difficulty confirms and reinforces the ordering of these passages in terms of difficulty. The significant effect of reader type means that recoding poor readers make more correct answers on average than whole-word poor readers, a finding which will be dealt with shortly.

Third, an error analysis was undertaken. Four types of errors were of interest here: single-word substitution errors, intrusions, omissions and unsuccessful attempts at correction. The total number of these types of errors made on a given passage was divided by the total number of words in a passage to yield a rough measure of error rate. In Figure 14 can be found the mean results plotted for each story and each reader group separately. Of course, good readers make very few errors (fewer than 5% in any story) and show an increase in error rate only for the level 5 story. Again, poor readers begin making more errors at about the level-3 story. A 2 x 6 analysis of variance on poor readers reveals a significant main effect of story difficulty, $F(5,50) = 36.3$, a significant effect of reader type, $F(1,58) = 29.4$, and a significant interaction, $F(5,50) = 3.67$.

To summarize, these three measures - reading time per word, number of comprehension questions correctly answered and proportion of errors all show that the passages are ordered in terms of difficulty and that good readers are much more able to handle even the difficult level-5 passage. Also, the two types of poor readers may be distinguished on the basis of differences in two of these measures -

FIGURE 14


MEAN PROPORTION OF STORY WHICH WAS MISREAD
.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
WHOLE-WORD POOR READERS
RECODING POOR READERS
GOOD READERS
PRE-P
L1
L2
L3
L4
L5
STORY

being indistinguishable only on the reading-time measure. This result again corresponds with similar differences found in Study 1 where no overall differences in reading time were found between the two groups but where measures of general accuracy showed a consistent advantage for recoding poor readers. This observed difference will be dealt with at greater length in the general discussion.

Error Analyses. Having established that the stories are ordered in terms of difficulty, analyses aimed at supporting the main predictions were undertaken. These analyses concerned errors and since good readers made so few, they will not be considered further. The error analyses were done by considering in greater detail two types of error: substitution errors and unsuccessful corrections. These errors are of interest since in each case of such an error, a comparison can be made between what was generated by a child and what was to be read. In the case of unsucccessful corrections, only the last attempt was considered. It should be noted that these two types of errors accounted for almost all (90%) of the errors generated. That is, relatively few omission or intrusion errors occurred. Further, most of the omission errors can be accounted for by the three line omissions which occurred.

The pre-primer story was not considered since almost no errors were made in reading it. The level 1, 2 and 3 stories were combined to form the "easy" set and the last two stories yielded the "hard" set. This seemed a good split based on the analyses of story difficulty. Also, three recoding poor readers made no errors on the easy set.

Thus, all analyses to be reported concern the remaining 7 recoding poor readers and the 10 whole-word poor readers.

These errors were tabulated in four different ways. First, the proportion of errors which were nonword errors was tabulated for the two types of poor reader and the easy and hard sets separately. As can be seen, from Figure 15, both types of poor reader made proportionately fewer nonword errors on the easy set. Means for recoding poor readers were .37(.06) and .07(.19) respectively, $\underline{t}(6) = 3.86$, and for whole word poor readers means were .15(.09) and .013(.04) respectively, $\underline{t}(9) = 6.43$. More importantly, the two types of poor reader differed on this measure for the hard set, $\underline{t}(15) = 5.32$, but not on the easy set, $\underline{t}(15) = 0.96$. This finding replicates that of Study 2 for random as opposed to categorized word lists.

Second, the proportion of errors which were conservative (see Study 1) was tabulated for the two types of poor reader and the easy and hard sets separately. Results are plotted in Figure 16. Again, the primary result of interest is that the two types of poor reader can be differentiated on this measure for the hard set, $\underline{t}(15) = 3.23$, but not on the easy set, $\underline{t}(15) = 0.88$. Taken together, the results for these analyses conceptually replicate Studies 1 and 2. In Study 1, random word lists were used. In such a situation, recoding poor readers can be differentiated from whole-word poor readers in that recoding poor readers' errors are more often nonword and conservative errors. This result was replicated in the control condition of Study 2 which is also a random word list situation. Hard stories in this study yield the same pattern of results leading to the conclusion that

FIGURE 15

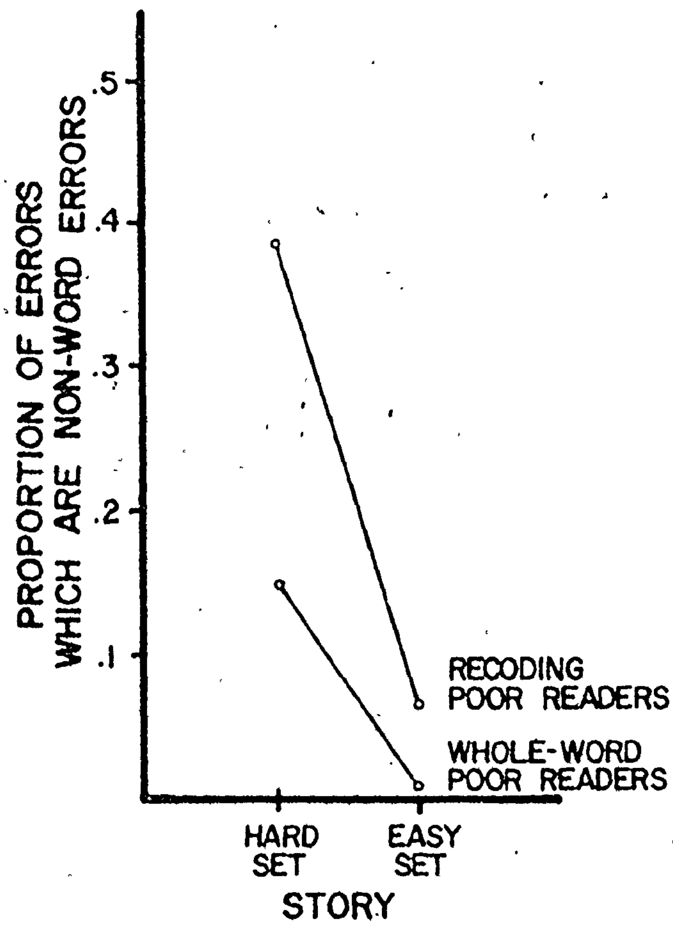
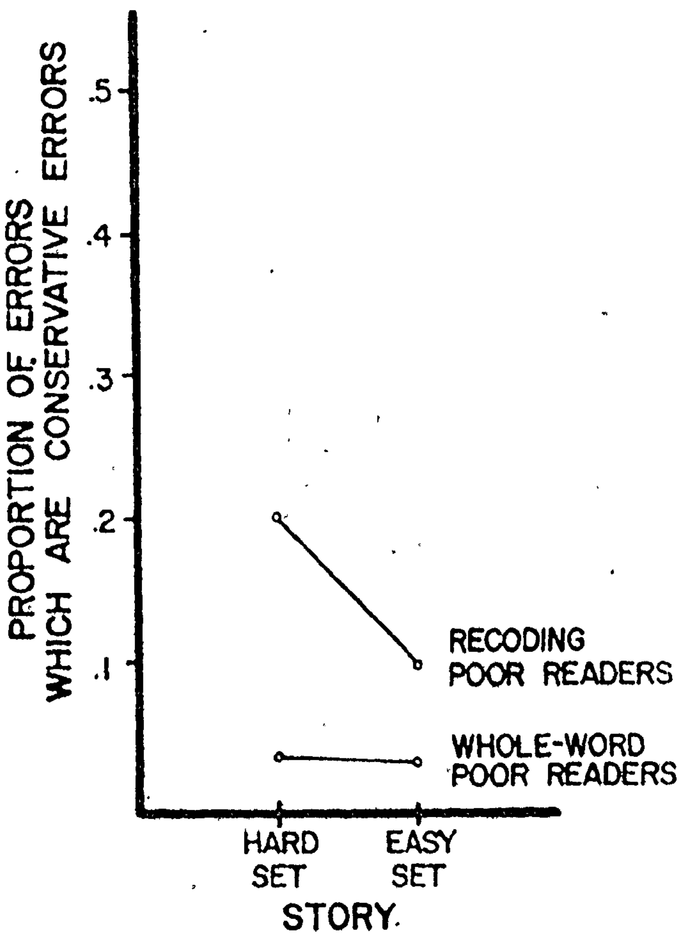

PROPORTION OF ERRORS
WHICH ARE NON-WORD ERRORS
.5
.4
.3
.2
.1
RECODING
POOR READERS
WHOLE-WORD
POOR READERS
HARD
SET
EASY
SET
STORY

FIGURE 16


PROPORTION OF ERRORS
WHICH ARE CONSERVATIVE ERRORS
.5
.4
.3
.2
.1
RECODING
POOR READERS
WHOLE-WORD
POOR READERS
HARD
SET
EASY
SET
STORY

difficult stories can be considered to be random word lists. That is, if a story is difficult enough to read, no context is available to aid in word identification.

In contrast, when semantic context <u>is</u> available either as category information as in Study 2 or in easy stories as in Study 3, a different pattern emerges. Now the available context guides guesses at unfamiliar words, literally overriding single-word identification strategies.

<u>Context Use</u>. The last two analyses of errors concerned indices of context use. It has been shown (e.g. Weber, 1970) that the substitution errors of grade-1 readers tend to preserve the syntactic category of the actual target word. To follow this up in the present study, those substitution and unsuccessful correction errors which were themselves words were classified as being in the same syntactic class as the stimulus word or not. In Figure 17 can be found plotted the proportion of the relevant word errors for hard and easy sets and for the two groups of poor readers separately. The only finding of importance here is that overall, more syntactically correct errors occur for the easy set than for the hard set, $t(16) = 2.57$.

The same errors were also classified as being semantically acceptable or not. The following types of errors were accepted as being semantically equivalent to the stimulus words: changes in tense, changes in pluralization, changes in determiners such as 'A' for 'THE' as well as synonym substitutions. In Figure 18 can be found plotted the proportion of word errors which were semantically consistent with the stimulus word for hard and easy sets and both groups of poor

FIGURE 17

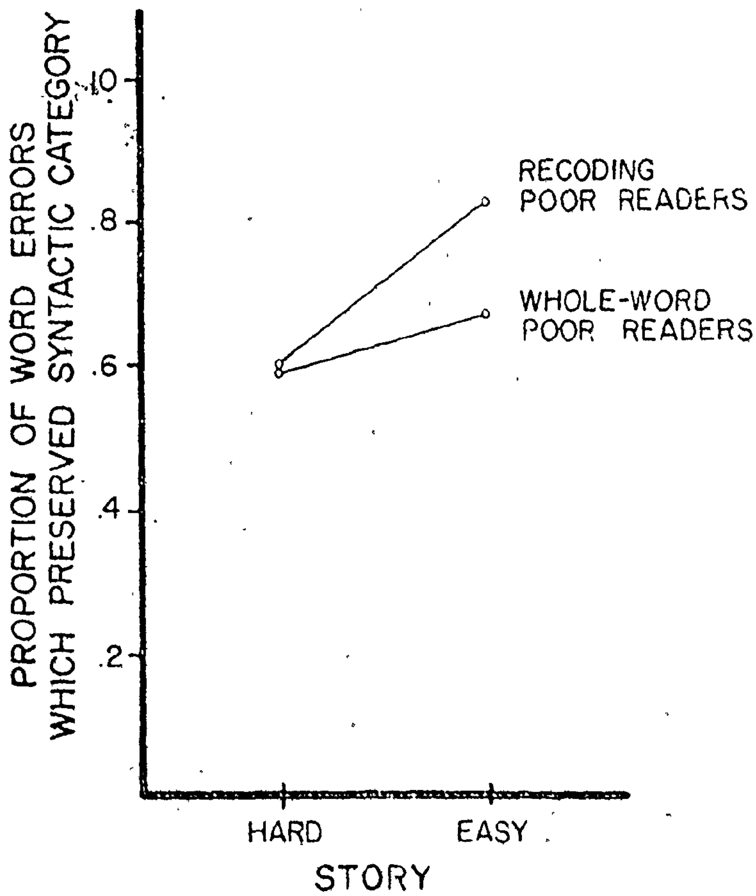
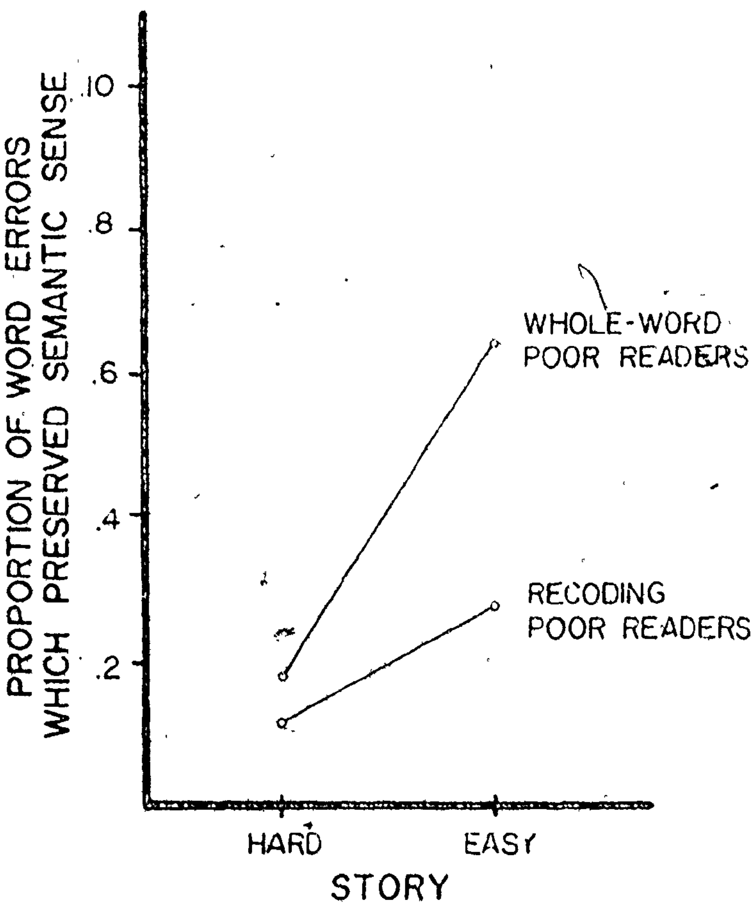

PROPORTION OF WORD ERRORS
WHICH PRESERVED SYNTACTIC CATEGORY
1.0
.8
.6
.4
.2
RECODING
POOR READERS
WHOLE-WORD
POOR READERS
HARD
EASY
STORY

FIGURE 18


PROPORTION OF WORD ERRORS
WHICH PRESERVED SEMANTIC SENSE
.10
.8
.6
.4
.2
WHOLE-WORD
POOR READERS
RECODING
POOR READERS
HARD
EASY
STORY

readers separately. The results parallel those found for the last analysis in that overall, more errors are semantically acceptable in the easy set than in the hard set, $t(16) = 4.90$. These two analyses simply confirm the successful operation of context in easy stories compared to hard stories.

To summarize, it seems that when stories are easy to read, few errors are made and contextual information can be used to aid in identification of unfamiliar words. This is reflected in the finding that many of the errors are semantically and syntactically constrained. As stories get harder, less contextual information is available for use as revealed by the lower proportions of syntactically and semantically constrained errors. As less contextual information is available to aid in word identification, readers are required to rely more upon single-word identification skills. Thus for easy stories, measures (proportion of errors which are conservative or non-word) which distinguish the two types of poor readers in the case of random word lists are not effective, presumably because contextual information overrides or in some other way modifies the best guess of the single-word identification skill. When such contextual information is not as available, it cannot as effectively mask the operation of the single-word skills resulting in the finding that measures indexing those skills again become diagnostically valid. The results of the current study as well as Study 2 indicate that both types of poor reader can use context to some degree to facilitiate the reading process at least when that context is easily available.

Such suggestions can be taken to imply that the ability to use context is perhaps the most important aspect of reading, overshadowing single-word identification skills wherever possible. This interpretation is only partly correct and may be seriously misleading. It must be kept in mind that the syntactic and semantic constraints used to aid in identifying an unfamiliar word have themselves arisen only because of the successful reading of prior segments of text. That is, some words have to be identified for contextual information to become available. It seems reasonable that until single-word recognition skills achieve some degree of proficiency, the role of contextual processes will be minimal. Until enough individual words are easily read to allow contextual processes some grist to grind, so to speak, they will remain silent. Thus, the preferred thesis is that deficits in single-word identification skills which have been documented in the current work underly poor reading even in contextually constrained situations. Reading proficiency will increase as single-word identification skills become more flexibly utilized.

General Discussion

At this time it is worth summarizing what has been claimed in the current thesis. In the introduction, evidence was presented which led to the assumption that good readers must be able to use both a recoding skill and a whole-word skill when identifying single words. It was further hypothesized that poor readers may be poor readers because they rely too exclusively on one or the other skill. This led to the major prediction of the thesis, namely that poor readers will be found to vary in the extent to which they depend on one or the other skill. In Study 1, definitions of the two reading skills were used to generate predictions about patterns of performance in the reading and spelling of a variety of verbal materials.

Subsequent factor analysis in fact yielded a first factor which could be identified as a recoding - whole-word factor. The results of this factor analysis were used to derive two groups of poor readers, indistinguishable in measures of general intelligence and overall reading ability but distinguishable on the basis of reliance on one skill as opposed to the other. Thus, groups of whole-word poor readers and recoding poor readers were isolated. A group of good readers, matched for IQ, was also included to verify the fact that the performance of the poor readers in subsequent tasks was indeed poor. It was noted that the good reading group fell intermediate between the two groups of poor readers on the recoding - whole-word factor in a factor analysis. This finding could be taken as evidence that good readers can and do use both skills. However, this finding needs to be tempered by the fact that the performance of the good readers was at ceiling in this study.

In Experiments 1 and 2, evidence was obtained establishing that recoding poor readers rely more heavily on the sound-based properties of words than do whole-word poor readers. Recoding poor readers were more able than whole-word poor readers to judge whether nonwords did or did not sound like real words in Experiment 1. In Experiment 2, a lexical decision task was utilized as a diagnostic for reliance upon sound based properties of words. In adults, nonwords which rhyme with real words are harder to reject as real words than nonwords which do not rhyme with real words. The interpretation of this finding is that adults rely on sound based properties of words in gaining lexical access. Using this diagnostic, it was found in Experiment 2 that recoding poor readers showed a pattern similar to that of adults while whole-word poor readers show no difference in the probability of rejecting the two types of nonwords. This finding was interpreted as showing that recoding poor readers rely on sound properties of words more than whole-word poor readers. In addition, a concurrent vocalization task which interferes with sound-based processing, interfered more with the performance of recoding poor readers than whole-word poor readers.

In Experiment 3, a short-term memory task was utilized to show that the two groups of poor readers cannot be distinguished in the use of sound-based properties of words to hold those words in STM. This result localized the difference in reliance on sound between good recoding poor readers and whole-word poor readers at the word identification process. Overall, as implied by the definitions of the recoding skill and the whole-word skill, it was found that poor readers relying on the recoding skill depended on sound-based properties of words more than poor readers depending on the whole-word skill.

Experiments 4 and 5 sought to show that whole-word poor readers depend more on visual properties of words, especially overall shape, than do recoding poor readers. While Experiment 4 was unsuccessful, in Experiment 5, whole-word poor readers' performance was interfered with more than recoding poor readers performance by reading of words printed in alternating upper case - lower case letters relative to normal purely lower case printing. Since printing in alternating upper case - lower case letters destroys word shape, a global, visual property of this finding lends support to the second major difference implied by the definitions of the reading skills. That is, readers relying on a whole-word skill depended more on overall word shape than readers relying on a recoding skill. Overall, Experiments 1 to 5 lend strong experimental support to the claims embodied in Study 1.

Studies 2 and 3 investigated the abilities of these poor readers to utilize higher-order context to aid in word identification, both category information (Study 2) and text information (Study 3). In both studies, performance of both groups of poor readers confirmed that their reading deficit did not arise from a total inability to use higher-order context as an aid in word identification. Unfortunately, ceiling performances by the good readers prevented a more detailed comparison of context use in good as opposed to poor readers. Thus, the hypothesis that poor readers are less efficient than good readers at using context could not be evaluated. As noted previously, the hysteresis hypothesis of Perfetti and Lesgold (in press) calls into question the idea that this hypothesis can ever be tested.

When looking at context use by these poor readers, an interesting point emerges. In Study 1, in the random word lists of Study 2 and the hard stories of Study 3, the two types of poor readers can be differentiated by analysing the types of errors (word-nonword, conservative-liberal) they make. Whole-word poor readers make more liberal, word errors and recoding poor readers make more conservative, non-word errors. However, when context is introduced, in Study 2 by grouping words in categories and in Study 3 by using easy stories, the two types of poor reader can no longer be distinguished. This finding suggests that attempts at word identification by single word identification skills are used in conjunction with contextual information to produce a 'best guess' for a word in question. That is, when higher-order context is available, poor readers can to some extent show flexibility by using that information.

Notice that when context is being used, the two types of poor reader are no longer distinguishable! A current implicit assumption in reading research is that "natural" or "real" reading situations must be studied in lieu of "artificial" situations if the processes involved in reading are to be understood. But in these studies, when more natural situations are used, very important single word strategy differences are obscured. Thus, "artificial" random word list situations seem to be valuable situations <u>in their own right</u> and the researcher who uncritically accepts the dictum "natural" is best may actually obscure rather than increase chances of uncovering important material.

Footnotes

(1) Actually there is a third difference between the two skills: the recoding skill involves a serial processing of letters within a word; the whole-word skill does not. However, in view of persuasive arguments that the serial-parallel processing issue is undecidable (Townsend, 1972), this difference will be ignored.

(2) These visual features can also be interpreted as the output of the simple cells of Hubel & Wiesel (1962).

(3) But note results of Shankweiler, D., Liberman, I., Mark, L.S., Fowler, C.A., and Fischer, F.W. The speech code and learning to read. <u>Journal of Experimental Psychology: Human Learning and Memory</u>, 1979, <u>5</u>, 531-545.

Appendix 1

Regular		Irregular		Nonsense	
alone	home	ache	island	anong	onswer
along	honey	among	key	bew	pache
ant	horse	answer	machine	bove	pone
blond	load	are	move	breat	poth
bone	nice	both	police	chine	potice
care	nine	broad	put	clde	sant
chew	page	come	sew	croad	spond
cloth	seat	does	shoe	fage	sutar
cut	stove	done	sponge	hoart	suth
dive	suck	garage	sugar	honer	sworp
eat	super	give	sure	islop	tave
few	switch	gone	sweat	koes	tey
fist	swore	great	sword	lut	tive
gave	toes	have	two	lare	tweat
hey	twelve	honest	want	mone	twop
hoe	which	hour	who	nome	whop

Stimulus items used in Study 1

Appendix 2

NON-WORDS WHICH RHYME WITH REAL WORDS	NON-WORDS WHICH DO NOT RHYME WITH REAL WORDS
bote	fote
cote	dobe
hoam	moab
hoal	soam
wate	nate
nale	dake
dait	gaik
caik	tait
seet	reet
heet	beel
feal	deat
grean	geal
brite	gite
tite	prite
kight	dight
bight	cright

Stimulus items used in Experiment 1

Appendix 3

SET A

words		nonwords	
cute	boat	bule	bight
dime	bright	dook	cote
fine	cake	dure	dait
fool	coke	fike	frite
four	fail	gire	grean
fruit	feel	hine	hait
help	fight	boon	heer
huge	game	mook	heet
look	home	noor	hoal
mile	keep	puit	nale
moon	kite	rell	noat
most	mean	sith	rale
roof	seat	sive	sean
tire	toad	tish	sope
went	wait	wown	tite
will	white	wust	wright

SET B

words		nonwords	
bite	book	belp	bote
coat	dive	bime	brite
date	down	bool	caik
fright	fire	cour	coak
green	fish	foon	fale
hate	like	gruit	feal
heat	line	fent	fite
heat	must	loof	gaim
hole	poor	nire	hoam
rail	rule	nost	kenp
note	soon	nole	kight
rail	suit	pook	meen
seen	sure	puge	seet
soap	took	rine	tode
tight	well	sile	wate
write	with	vill	wight

Stimulus items used in Experiment 2

Appendix 4

HARD SET	EASY SET
bite-bight	black-blak
boat-bote	blue-blod
brite-bright	kame-came
caik-cake	cum-come
coat-cote	funny-funi
date-dait	little-litle
feal-feel	maek-make
grean-green	noo-new
heat-heet	play-plae
hole-hoal	please-plese
hoam-home	sed-said
kight-kite	staup-stop
nail-nale	thought-thaut
seat-seet	three-threa
tie-tight	white-wite
wate-wait	yello-yellow

Stimulus items used in Experiment 4

Appendix 5

SET A		SET B	
after	play	away	live
again	please	back	look
brown	ride	before	make
came	right	black	must
down	said	blue	once
every	shout	could	pretty
find	soon	feel	round
first	take	four	sing
give	thank	from	some
have	three	going	stay
help	under	good	stop
into	want	green	that
just	where	happy	there
know	white	hello	think
open	with	here	walk
over	yellow	jump	well

Stimulus items used in Experiment 5

Appendix 6

CATEGORY	CLOTHING	FURNITURE	FRUIT	BODY PART	ANIMAL
6 "easy" items	shirt	desk	apple	head	monkey
	dress	table	banana	tooth	bear
	shoes	chiar	cherry	arms	rabbit
	belt	stove	plum	neck	mouse
	skirt	stool	peach	hair	elephant
	jacket	couch	lemon	face	camel
4 "hard" set A items	pants	stereo	strawberry	elbow	turtle
	socks	refrigerator	tangerine	mouth	buffalo
	girdle	mirror	apricot	muscles	raccoon
	nylons	bench	raisin	thighs	leopard
4 "hard" set B items	blouse	dresser	raspberry	stomach	moose
	vest	television	pineapple	shoulders	antelope
	sweater	cabinet	cantalope	finger	giraffe
	scarf	piano	grape	ankle	tiger

Stimulus items used in Study 2

Appendix 7

1. Look, Mother, look.
   See me go.
   I go up.
   I come down,
   Come here, Mother.
   Come and play with me.

2. A boy said, "Run, little girl."
   "Run with me to the boat."
   They ran and ran.
   "This is fun," said the boy
   "Look," said the girl.
   "I see something in the boat."
   "It is my kitten."
   "She wants to play."

3. One morning a boy made a boat.
   "Where can I play with it? he asked.
   Father said, "Come with me in the car!
   We will take your boat with us,"
   Soon the boy called, "Please stop. I
   see water. May I play here?"
   "Yes," said Father. "Have a good time."

4. One day five children went out to play in the beautiful white snow. They played for a long time and then began to make snow animals. One of the animals was a dog. Soon the dog next door came out of the house. When he saw the snow dog he said, "Bow-wow." The children laughed. "Now we have a dog that can bark."

5. It was pet day at the fair. The children were waiting for the parade of animals to begin. They had trained their pets to do many different tricks. Among them was a tall boy whose goat made trouble for him. It kicked and tried hard to break away. When it heard the band it became quiet. During the parade it danced so well that it won a prize.

6. Airplane pilots have many important jobs. They fly passengers, freight, and mail from one city to another. Sometimes they make dangerous rescues in land and sea accidents, and drop food where people or herds are starving. They bring strange animals from dense jungles to our zoos. They also serve as traffic police and spot speeding cars on highways.

Stimulus stories used in Study 3.

Appendix 8

1. 1. What was the girl in this story doing?
   2. Who was she talking to?
   3. What two things did the girl ask Mother to see her do?
   4. Who was Mother to play with?

2. 1. Where did the boy want the girl to run?
   2. Who said it was fun to run?
   3. What was in the boat?
   4. Who saw the kitten first?

3. 1. What did the boy make one morning?
   2. What did he say he wanted to do with it?
   3. What did the boy see as they rode in the car?
   4. When he saw the water what did he ask his father to do?

4. 1. In what were the children playing?
   2. What did they make out of the snow?
   3. While they were playing what came out of a house?
   4. What did the children say the real dog could do?

5. 1. What day was it at the fair?
   2. What had the children trained their pets to do?
   3. What animal made trouble for one boy?
   4. What did the goat do that won a prize?

6. 1. Whom is this paragraph about?
   2. What do they take from city to city?
   3. What kind of rescues are sometimes made in land and sea accidents?
   4. What do airplane pilots do when serving as traffic police?

Comprehension questions used in Study 3

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EDUCATION

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McMaster University
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EXPERIENCE

Research Assistant - University of Calgary
(1) R. Schaub & R. Sainsbury, September 1969 - 1970
Execution of Animal Learning Experiments
(2) D. Bakal, April 1974 - August 1974
Survey on Drug Use in Rural Alberta

Teaching Assistant - McMaster University

(1) Cognitive Psychology for L. Brooks	Sept. 1974 - Apr. 1975
(2) Human Memory for B.A. Levy	Sept. 1975 - Apr. 1976
(3) Developmental Psychology for L. Jacoby	Sept. 1976 - Dec. 1976
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GRADUATE EDUCATION

Courses

(1) Contemporary Problems, (Graduate Survey Course)	Sept. 1974 - Apr. 1975*
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GRADUATE EDUCATION (Cont'd)

Courses

(3) Cognitive Psychology, (An Ongoing Cognitive Psychology Course/Seminar)

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(1) An Analysis of Memory	B.A. Levy	January 1976
(2) Concept Formation	L. Brooks	April 1976
(3) Study of a Monograph by Francis Irwin: Intentional Behavior and Motivation	H. Jenkins	July 1976
(4) Language Development	D. Maurer	October 1976
(5) Theoretical Structures of Animal Behavior and Cognitive Psychology	B. Galef	July 1977
(6) Attitudes and their Theoretical Structure	D.W. Carment	October 1977
(7) Grammars, Automata & Theories	I. Begg	October 1977
(8) Some Aspects of Reading Theory and Practive	L. Brooks	December 1977

REFERENCES

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Cognitive Development - Intellectual
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Reading - Text Grammars

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THESES

Honors: Picture Memory: The Role of Figure - Ground Organization. Supervised by G.L. Rowland.

Dissertation: Strategies in Single Word Identification and Learning" The Effects of Context and Individual Differences. Supervised by Ian Begg.

PUBLICATIONS

Mitterer, J.O., & Rowland, G.L. Picture memory: Role of figure-ground organization. Perceptual and Motore Skills, 1975, 40, 753-754.

Bacon, F.T. Credibility of repeated statements: Memory for trivia. Journal of Experimental Psychology: Human Learning & Memory, 1979, 5, 241-252. Note:; F.T. Bacon is a research group whose members are Ian Begg, Grant Harris, John Mitterer and Douglas Upfold. (See Footnote 1 in the article).

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CONFERENCE PAPERS

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